HISTORIC STRUCTURE REPORT

NHL FERRYBOAT EUREKA

National Park Service | *September 2022 - 100% Final*

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Section One

Study Summary

INTRODUCTION

At the request of the National Park Service (NPS), Architectural Resources Group (ARG) prepared this Historic Structure Report (HSR) for the ferryboat *Eureka* (PMIS 227029). The *Eureka* is one of six historic vessels at San Francisco Maritime National Historical Park (SAFR) and includes the only known example of a walking beam marine engine afloat in North America. The HSR documents the evolution of the vessel, describes modifications and existing conditions, outlines historic preservation objectives, and provides recommendations for an overall treatment approach. This document serves to inform future planning efforts for the vessel as San Francisco Maritime National Historical Park (SAFR) evaluates options for rehabilitation and continued use.

The *Eureka* was built in 1890 as the *Ukiah*, designed by Patrick H. Tiernan and built by John Dickie at the San Francisco and North Pacific Railway yard in Tiburon, California. Built to ferry passengers and railcars, the vessel was used to transport munitions during World War I and then rebuilt in 1922 around her massive walking beam engine and existing keel. Renamed the *Eureka*, the vessel transported passengers and automobiles between San Francisco and Sausalito through 1941 when the route was cancelled due to waning ridership. After service during World War II, the *Eureka* connected Southern Pacific's transcontinental rail passengers between the Oakland Mole and San Francisco; when a crankpin snapped in 1957, the vessel was retired from service. Southern Pacific donated the *Eureka* to the San Francisco Maritime Museum in 1958 and the vessel has been at Hyde Street Pier since 1964. The *Eureka* was placed on the National Register of Historic Places in 1974 and listed as a National Historic Landmark in 1985.

CONTENTS OF THE HISTORIC STRUCTURE REPORT

The contents of this HSR comply with NPS Director's *Order 28: Cultural Resource Management Guideline*, Chapter 8 and *Preservation Brief 43*: *The Preparation and Use of Historic Structure Reports*. This HSR conveys information about the design and construction of the *Eureka* in two main sections: 1) Developmental History and 2) Treatment and Work Recommendations. The Developmental History section comprises a chronology of development and use; a historical background and context; a physical description and a list of character-defining features and materials; and a discussion of significance. This section also provides a comprehensive conditions survey and significant changes assessment.

The Treatment and Work Recommendations section provides a comprehensive set of objectives and recommendations for the *Eureka*. The proposed treatment has been developed in accordance with *The Secretary of the Interior's Standards for Historic Vessel Preservation Projects with Guidelines for Applying the Standards (The Standards).*

PROJECT GOALS

According to National Park Service *Preservation Brief 43*, an HSR provides documentary, graphic, and physical information about a resource's history and existing conditions. Broadly recognized as an effective part of preservation planning, an HSR also provides a thoughtfully considered argument for selecting the most appropriate approach to treatment prior to the commencement of work and outlines a scope of recommended work. The *Eureka* HSR serves as an important record of the history of the vessel changes made to the vessel to date, and as a guide for future treatment and use.

METHODOLOGY

The *Eureka* HSR has been developed using information gathered from existing documentation, meetings with NPS staff, archival research, and field investigation. The methodology employed for this report meets the standards and requirements set forth in the following documents:

- The Secretary of the Interior's Standards for Historic Vessel Preservation Projects with Guidelines for Applying the Standards
- NPS Director's Order 28: Cultural Resource Management Guidelines
- NPS National Register Bulletin 20: Nominating Historic Vessels and Shipwrecks to the National Register of Historic Places
- Preservation Brief 43: The Preparation and Use of Historic Structure Reports

Meetings

ARG attended an initial project meeting with representatives from SAFR on October 6, 2021. The project scope, objectives, coordination, schedule, information gathering, compliance process, and procedures were discussed at this meeting. The initial project meeting also reviewed major site issues and management decisions that may impact the recommendations for treatment and use of the vessel. Those primary issues were further discussed at follow-up meetings on December 10, 2021 and January 19, 2022. Primary issues include:

- Hull condition and alternatives for repair;
- Configuration of the restaurant/ café; and
- Disabled access to the vessel.

Background Research and Data Collection

ARG visited the San Francisco Maritime National Historical Park Research Center at Fort Mason in October 2021 to collect existing primary and secondary source documents related to the *Eureka* and its development over time. The archival materials collected include historical photographs, maintenance and repair reports, and correspondence.

Field Investigation and Condition Assessments

ARG staff conducted initial field investigations in September 2021 onboard the *Eureka* at the Hyde Street Pier.

RESEARCH FINDINGS

A significant amount of research and context development for the *Eureka* was completed for the 1973 and updated 1984 National Register of Historic Places Nominations, for a 2001 Addendum to Historic American Engineering Record (HAER) documentation; a Draft Historic Structure Report in 1990; chronologies of the vessel's development assembled by National Park Service staff; and in recent engineering reports. ARG has incorporated pertinent information from these documents into this HSR, updated information where relevant, and completed additional archival research to confirm and expand the historical record for the vessel.

MAJOR ISSUES IDENTIFIED

From the comprehensive conditions survey conducted in 2019, and described in Part II, the *Eureka* has numerous structural components that were and remain critically compromised. Its hull is near the end of its life with significant decay in the wood timbers and advanced corrosion in the metal fasteners which hold the vessel's timbers together.

TREATMENT AND WORK RECOMMENDATIONS

Discussions regarding *Eureka's* existing hull condition, and what alternatives could be considered for repairing or replacing the hull, were held by the National Park Service in December 2021 and January 2022. Three hull treatment alternatives were presented:

Alternative 1 – Replacement in Kind

- Replacement of the *Eureka* hull with new in-kind material copying the original shapes, sizes, and methods of construction.

Alternative 2 – Removal from the Water

- Remove the vessel from direct contact with open water and preserve the *Eureka* as an object.

Alternative 3 – Recreate Hull with Non-historic Materials

- Replacement of the hull in its entirety with new construction and materials, duplicating the shape, profile and finished appearance of the original construction.

See Section 10 for more detail and the descriptions of work recommendations.

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Section Two

Administrative Information

STRUCTURE INFORMATION

Original Name:	*Ukiah* (1890 - 1921) *Eureka* (1921-present)
NPS Preferred Structure Name:	*Eureka*
Current Name:	*Eureka*
Location:	San Francisco Maritime National Historical Park, San Francisco, California
Construction Date:	1890; rebuilt around original engine and keel, 1922
Designer:	Captain Patrick H. Tiernan (1890)
Shipbuilder:	John Dickie for the San Francisco and North Pacific Railway (1890) Charles Green for the Southern Pacific Railway (1922)
Historic Use:	Passenger ferry; railcar ferry; automobile ferry; military ammunition transport; military troop transport; freight transport
Current Use:	Education, Interpretation
Designations:	Listed on the National Register of Historic Places on February 28, 1973; designated a National Historic Landmark on February 4, 1985.

PREVIOUS DOCUMENTATION AND STUDIES

For the preparation of this HSR, ARG reviewed several existing studies (listed in the Bibliography), including the following key reports:

- National Register of Historic Places Inventory Nomination Form for the *Eureka*, prepared by California Department of Parks and Recreation historian Allen W. Welts in 1973;
- National Register of Historic Places Inventory Nomination Form for the *Eureka*, prepared by National Park Service Ranger Stephen Haller in 1984;
- Addendum to the Historic American Engineering Record (HAER) recordation for the *Eureka*, prepared by historian Marc R. Porter in 2001;
- Draft Historic Structure Report (HSR) for *Eureka* completed by Tri-Coastal Marine, Inc. in 1990;

Administrative Information

- Assessment of Fastener Corrosion and Salt Damage in the Bilge of the *Eureka*, prepared by Samuel L. Zelinka and Grant T. Kirker in 2018;
- Physical chronology of the *Eureka*, and installation of oil-burning boilers, prepared by SAFR Park Ranger Chris Edwards in May 2020;
- Preliminary Engineering Report - Ferryboat *Eureka* Critical Systems, completed by Mott MacDonald in 2020; and
- Final Task Order Report on the Structural Condition the Ferry *Eureka*, completed by Anthony Guild in 2021.
- Assessment of fastener corrosion and salt damage in the bilge of the *Eureka* – Interim report prepared by Samuel L. Zelinka and Grant T. Kirker, 2022?.

Part 1: Development History

Section Three

Historical Background

INTRODUCTION

The historical overview below is adapted from the National Register of Historic Places Inventory Nomination Form for the *Eureka*, prepared by California Department of Parks and Recreation historian Allen W. Welts in 1973; an updated National Register of Historic Places Inventory Nomination Form for the *Eureka*, prepared by National Park Service Ranger Stephen Haller in 1984; Addendum to the Historic American Engineering Record (HAER) recordation for the *Eureka* prepared by historian Marc R. Porter in 2001; a Draft Historic Structure Report (HSR) for the *Eureka* completed by Tri-Coastal Marine, Inc. in 1990; a physical chronology of the vessel and of the installation of oil-burning boilers, prepared by SAFR Park Ranger Chris Edwards in 2020; research on the *Ukiah* conducted by SAFR historian Katherine Hijar; Preliminary Engineering Report - Ferryboat *Eureka* Critical Systems completed by Mott MacDonald in 2020; and Final Task Order Report on the Structural Condition the Ferry *Eureka*, completed by Anthony Guild in 2020. ARG has revised, condensed, and updated narrative components of these reports for the purposes of this document, and completed archival research, secondary source research, and site work to supplement and clarify the existing material.

FERRYBOATS ON THE SAN FRANCISCO BAY

The story of ferryboats on the San Francisco Bay predates the Gold Rush, as pioneering businessman Alexander Leidesdorff was operating a small steam ferry between San Francisco, the East Bay, and Sacramento as early as 1847.[1] The onset of the Gold

Paddle boats including ferry Paul Pry *at Broadway Street wharf, 1866 (San Francisco Maritime National Historical Park [SAFR], Catalog ID no. SAFR 21374)*

Rush and the concordant population boom increased demand for reliable trans-bay ferry service. The first steamboat to make regular crossings between Oakland and San Francisco was the *Kangaroo*, which established service in 1850.[2] By 1863 two competing companies were operating four steam ferries that served local railroads by carrying offboarding passengers around the bay.[3] When the first transcontinental railroad reached its terminus in Alameda in 1869, it was met by the ferry steamer *Alameda,* which transported passengers across the bay to the Davis Street wharf in San Francisco.[4]

Regular ferry service was established between San Francisco and Marin County in 1868 when the *Princess* began running between Sausalito and Meiggs' Wharf, near the current location of Powell and Francisco streets. Ferry service quickly became affiliated with the handful

[1] Stephen Haller, National Park Service, Eureka *National Register of Historic Places Inventory Nomination Form,* San Francisco, CA, 1984, Section 8, Page 2.
[2] Haller, Eureka *National Register Form*, Section 8, Page 2.
[3] Haller, Eureka *National Register Form*, Section 8, Page 2.
[4] Dennis Evanosky,"Alameda in History: Failed Railroad led to Thriving Ferry Service," *Alameda Sun,* July 17, 2015.

of rail companies operating in the area, including the San Francisco and North Pacific, the Southern Pacific and Northwestern Pacific, and the North Shore Railroad.[5] In 1890, the San Francisco and North Pacific Railroad commissioned the construction of the ferryboat *Ukiah*, later renamed *Eureka*, to transport rail cars, freight, and passengers between San Francisco and its routes' southern terminus in Tiburon, California.

By the turn of the twentieth century there were nearly thirty major ferry routes operating on the San Francisco Bay, most of which were operated by or adjunct to the railroad lines that they served.[6] Prior to the emergence of the automobile, ferries served as the last leg of the journey for passengers and freight upon the numerous short line and inter-urban train routes that ringed the Bay Area. During World War I, scores of ferries operating in the Bay Area were placed under operational control of the newly established United States Railroad Administration, and placed into service of the war effort, often carrying munition-filled rail cars.

The emergence of automobiles in the first decades of the twentieth century precipitated the decline of ferry service in several ways. Auto ownership amongst the general population curtailed use of short line and inter-urban rail, and when these lines disappeared, associated ferry lines either shuttered or converted their main decks to carry autos rather than rail cars. Auto ferries rapidly ended service in the years after the major bridges opened to span the San Francisco Bay, including the Carquinez Bridge in 1927, the San Francisco-Oakland Bay Bridge in 1936, the Golden Gate Bridge in 1937, and the Richmond-San Rafael Bridge in 1956. Once the dominant form of trans-bay travel, ferries became relegated to limited run services, including providing access to the Golden Gate International Exposition on Treasure Island in 1939-1940; transporting shipyard workers from San Francisco to Richmond and Sausalito during World War II; and providing sightseeing trips around the bay for the city's burgeoning tourist trade.[7]

[5] Haller, Eureka *National Register Form*, Section 8, Page 2.

[6] George H. Harlan, *San Francisco Ferryboats* (Berkeley, California: Howell-North Books, 1967) 15.

By 1958, no commuter ferry lines operated on the San Francisco Bay. However, starting in the mid-1960s as auto traffic on Bay Area freeways increased, passenger ferry service lines were reestablished, starting with service between San Francisco and Tiburon in the 1960s, followed by service between San Francisco and Sausalito in 1970, San Francisco and Larkspur in 1976, and San Francisco and Vallejo in 1986. The Loma Prieta Earthquake in 1989 damaged the San Francisco-Oakland Bay Bridge and spurred the introduction of ferry service between San Francisco, Oakland, and Alameda. This array of ferry services in the San Francisco Bay is now operated under Golden Gate Ferry, a division of the Golden Gate Bridge, Highway and Transportation District, and the Water Emergency Transit Authority under the name San Francisco Bay Ferry.

WALKING BEAM ENGINES

The *Eureka* is powered by the last known example of a walking beam engine preserved in a floating vessel in the United States.[8] The beam engine is a type of steam engine where a pivoted overhead beam is used to apply force from a vertical piston to a vertical connecting rod. The earliest iterations of the beam engine were used to remove water from mines in England around the turn of the eighteenth century. Design improvements in the later part of the eighteenth century increased the beam engine's efficiency and these improved variations were used in mining and industrial application in England and Europe throughout the nineteenth century.[9]

[7] Haller, Eureka *National Register Form*, Section 8, Page 5; Harlan, *San Francisco Ferryboats*, 25.

[8] R. Damian Nance, "The Paddle Steamer *Eureka* and its Walking Beam Engine," *International Stationary Steam Engine Society Bulletin*, January 2018, 50.

[9] I. C. B. Dear and Peter Kemp, eds., "Walking Beam Engines," published in *The Oxford Companion to Ships and the Sea* (Oxford: Oxford University Press, 2006) published online, accessed April 27, 2022 at https://www.oxfordreference.com/view/10.1093/oi/authority.20110803120655188.

The walking beam engine is a design iteration of the beam engine wherein the piston is mounted vertically, and the piston rod drives the beam. A connecting rod from the other end of the beam, rather than driving a pump rod, now drives a flywheel. This engine type powered the first steam powered ships; when used aboard a ship, the beam or beams were often located abovedeck to take up less onboard room.[10]

Called a "walking beam" because of its visible steady rocking action, the beam, often reinforced with iron struts that gave it a characteristic diamond shape, pivots in the center, transmitting the vertical motion of the engine's single large piston to the shaft which turns the paddlewheels. In many cases, beams and supporting structures were constructed of wood, which lowered the construction cost for this type of engine, although many were later constructed of or replaced with iron and steel.

The walking beam engine entered into widespread use in the United States in the late nineteenth and early twentieth centuries, and primarily powered the sidewheel steamboats and steamships that provided coastal service and navigated inland waterways.[11] The engine was rarely used for screw-type propeller power or for seagoing vessels, because the required vertical height of the engine made it less stable in heavy seas. The walking beam engine was also of limited military use, as the exposed upper portion of the engine could be easily targeted and disabled.

However, the walking beam engine was well suited for shallow-draft application of the sidewheel steamboat. With the vertical arrangement of the engine and the beam rocking above the uppermost deck, the walking beam engine allowed for spacious passenger accommodation and substantial cargo capacity. Side paddlewheels provided great ease of handling and navigation in shallow waters, even when the vessel was large. This type of vessel has been described as integral to the westward expansion of

Walking beam engine with A-frame support at the Eureka, *exposed during rebuild ca. 1921 (SAFR, Catalog ID no. SAFR 21374)*

America prior to the growth of railways, and served almost every coastal and inland port from as early as 1811 until after the Second World War.[12]

The walking beam engine became technically obsolete in the later part of the nineteenth century, and the last of its type was reportedly built in 1924.[13] However, existing examples remained in use and popular into the early twentieth century. Technical reasons for retaining a walking beam engine included its comparative simplicity to repair and maintain, and economical cost based on the use of wood for some engine components. The relatively low cost of fuel also mitigated the lower efficiency of the walking beam, and excursion steamer passengers often enjoyed seeing the "walking beam" in motion. However, steamboat travel was largely extinct by the mid-twentieth century, as automobile travel and the rise of short-haul airline travel supplanted the need for these vessels. The *Eureka* was the last operating walking beam engine steamboat when it was taken out of service in 1957.[14]

[10] Dear and Kemp, "Walking Beam Engines."
[11] Nance, "The Paddle Steamer *Eureka*," 49.
[12] Nance, "The Paddle Steamer *Eureka*," 49.
[13] Nance, "The Paddle Steamer *Eureka*," 49.
[14] Nance, "The Paddle Steamer *Eureka*," 49.

FERRYBOAT *EUREKA*

Ukiah Era (1890-1921)

Predecessor to the *Eureka* was the *Ukiah*, a railcar and passenger ferryboat constructed in 1890 for use by the San Francisco and North Pacific Railroad company. The *Ukiah* was designed by master shipbuilder Captain Patrick H. Tiernan and built by John Dickie at the San Francisco and North Pacific Railway yard in Tiburon, California.[15] Patrick H. Tiernan was born in Ireland in 1827 and raised in upstate New York along the St. Lawrence River.[16] He learned shipbuilding as an apprentice in Clayton, New York, and later built and operated steamboats in Chicago and around the Midwest.[17] He moved to San Francisco in 1853 and quickly established himself as one of the Bay Area's most prolific shipbuilders. Between 1856 and 1890, Tiernan built or designed approximately forty-six vessels, including at least nineteen steamboats.[18] In 1883 he was hired by Peter Donahue, President of the San Francisco and North Pacific Railway, to design a vessel for that company, the double-ended ferry *Tiburon*.[19] Six years later, Tiernan modeled, drafted, and superintended builder John Dickie in the construction of the *Ukiah* for the San Francisco and North Pacific Railway.[20] Tiernan retired shortly after completion of the *Ukiah*.[21]

The purpose of the *Ukiah* was to connect travelers and rail cars to San Francisco from the southern terminus of the rail company's northern California routes, including the recently completed extension to the city of Ukiah, hence the new vessel's name. While under construction, the vessel was hotly anticipated in the press due to her large size, first-class rating, and potential for quick speed.[22] After an initial launch in May 1890, the *Ukiah* completed several public demonstration runs before commencing regular ferry service between San Francisco and Tiburon on January 8, 1891.[23]

Ukiah *steaming to Tiburon, 1894 (San Francisco Public Library (SFPL) Historical Photograph Collection, ID no. AAH-0282)*

At 291' in length of the deck, 78' 8" across the beam of the deck, and 2,564 tons gross register, the *Ukiah* had a varyingly reported capacity of between ten and eighteen rail cars and well over one thousand passengers on trips where no rail cars were present, making it the largest ferry on San Francisco Bay other than a massive rail car ferry called the *Solano*.[24] The entirety of the vessel was manufactured and constructed in California, with the walking beam steam engine constructed by the Fulton Iron

[15] E. M. North, "Evolution of Shipping and Shipbuilding in California," *Overland Monthly*, 1899, 151.
[16] "Tiernan," *San Francisco Call*, February 8, 1910, 11; North, "Evolution of Shipping and Shipbuilding," 143-144.
[17] North, "Evolution of Shipping and Shipbuilding," 143-144.
[18] *List of Merchant Vessels of the United States*. Washington: Government Printing Office, 1868, 1876; *Thirtieth Annual List of Merchant Vessels of the United States*. Washington: Government Printing Office, 1898.
[19] "The '*Tiburon*'," *Daily Alta California*, January 29, 1884, 1; North, "Evolution of Shipbuilding," 150.
[20] North, "Evolution of Shipping and Shipbuilding," 151.
[21] North, "Evolution of Shipping and Shipbuilding," 153.
[22] "Monster Ferry Boat," *Statesman Journal* (Salem, Oregon), October 8, 1890, 1.
[23] "A Magnificent Steamer," *Ukiah Daily Journal*, January 2, 1891, 2; "The *Ukiah*'s First Regular Trip," *Daily Alta California*, January 9, 1891, 2.
[24] "A Fine Ferry Boat," *San Francisco Chronicle*, December 28, 1890, 18; "Trial Trip of the Ukiah," *The Morning Call* (San Francisco), December 28, 1890, 7.

Works in San Francisco.[25] The configuration and operation of the engine, which remains present in the *Eureka* with largely in-kind repairs (exceptions noted in later text), is described by marine engine historian R. Damian Nance as such:

> "The cylinder, which lacks a steam jacket, is 65 inches in diameter with a 12-feet stroke, and the engine was operated at 24 revolutions a minute delivering 1500 horsepower. The working principle is that of a double-acting rotative engine with the crosshead from the cylinder and the connecting rod to the paddle crank linked by a cast-iron beam, the pivoting shaft (or trunnion) of which was supported on an oak (and later riveted steel) A-frame fastened to the keelsons of the vessel. A third pair of legs ahead of, and braced to, the front legs of the A-frame, provide forward support for the main bearings of the paddlewheel shaft.
>
> "The hollow-work beam is of a flattened diamond shape and comprises a single cast-iron beam with a central hub for the trunnion and several projecting arms, over the ends of which a wrought iron strap was shrunk for strength. The strap is further secured to the arms by U-shaped wrought iron bands. Two links connect the crosshead to the beam and crosshead guides anchored to the A-frame kept the piston vertical in the cylinder. A long, wrought-iron connecting rod turned the massive two-armed crank, which is linked directly to the shaft of the paddlewheel.
>
> "The engine is double acting with four valves (steam inlet and exhaust, top and bottom) operated by curved cams or 'wipers' that acted on followers or 'toes' affixed to vertical rods or 'lifters.' These, in turn, operated the Stevens valve gear that worked double poppet steam and exhaust valves at the upper and lower ends of two 'side pipes' that stand vertically behind the valve gear and are linked top and bottom by transverse steam chests. The curved cams that operated the valves are set on a pair of in-line, horizontal arbors or 'rock shafts' in the center of the valve gear that share a common central bearing and were rotated backwards and forwards by actuating arms from two sets of eccentrics on the shaft of the paddlewheel."[26]

Nance also describes the starting and steam operations of the walking beam engine:

> "To start the engine, the throttle would be set to about half speed while the valves were operated by hand using a starting bar. Set at a 45-degree angle in a secondary camshaft located just below deck level, this would be raised or lowered to work the valves as the situation required, the amount of movement being increased as the boat gained speed until the bar was being swung through an arc of almost 90 degrees. At this point the eccentric rods were lowered so that U-shaped notches at their ends engaged the rock shafts of the valve gear and the motion became automated – a maneuver known as 'dropping the hooks.' Only at this point would the steam throttle be opened fully, and attention turned to feeding water to the condenser in order to pick up the vacuum. Stopping the engine employed a similar procedure in reverse. The throttle was partially and then fully closed, the steam and exhaust hooks were pulled, and the piston given a little steam in reverse to bring the boat to a halt.
>
> "The easily accessed starting bar was also used to reverse the engine and to ensure, before its motion fully ceased, that the piston did not come to rest at either top or bottom dead center (which locked the engine) when the engine came to a stop. An indicator on the wall with a single pointer timed to follow the rotation of the paddlewheel crank was used to determine the position of the engine. A fully locked

[25] "A Magnificent Steamer," *Ukiah Daily Journal*; North, "Evolution of Shipping and Shipbuilding," 151.

[26] Nance, "The Paddle Steamer *Eureka*," 54-60.

> engine could only be turned over by levering one of the paddles through an access door in the paddle box."[27]

Steam was originally supplied by two Flue Return Tubular coal-fired boilers, which were reconfigured to oil-fired boilers in 1906 and replaced by four oil-burning Freeman Dryback Fire Tube boilers in 1914. With four boilers, one could be cooled down for maintenance while three could work to power the ship. The steam was first piped through a steam chimney around the base of the stack that functioned as a limited superheater and then on to the cylinder at a pressure of 60 psi.[28]

Returning again to Nance for a description of the engine's condensing operation:

> "The engine's original condenser was a 'jet' condenser that sat atop the bed plate immediately beneath the cylinder. Condensation was effected by injecting cold water into the steam [replacement with 'surface' condenser described in later text]. Contrary to usual practice, the boiler feed pump was not worked off the main engine but was, instead, operated by a small auxiliary steam engine. This was to ensure that water would continue to be fed to the boilers when the engine was stopped, which was a frequent occurrence in the life of a short-run ferry. Steam-driven dynamos provided electricity for lighting."[29]

Above the hull, the *Ukiah* was configured to include a main deck and a hurricane deck. The main deck included a deck house with a 17' height. Within the deck house, rail tracks were confined to the 42' wide area of the deck above the hull, and men's and women's passenger cabins were located at the port and starboard sides of the deckhouse, on the sponsoned portion of the main deck.[30] Cabins were fitted with vestibule doors at either end; the women's cabin featured red velvet carpet, while the men's cabin was carpeted in oilcloth. Both cabins were steam heated. There was also a restaurant and bar at the main deck, with the ship's machinery and quarters for sixteen crewmen located below. The hurricane deck was accessible to passengers via what was described in the press as a double gangway and provided an uninterrupted walking space save for the presence of the two pilothouses.[31]

At top speed, the *Ukiah* could make the journey from San Francisco to Tiburon in just twenty-two minutes.[32] Veteran steamship operator Captain D. F. Van Pelt piloted the vessel on her first regular service run. While constructed with a manual steering system and wheel, sometime after she was launched the *Ukiah* received two double cylinder steering engines, designed and patented by master mechanic John Bonner.[33]

The *Ukiah* typically moved rail cars at night, and passengers and sometimes rail cars during its daytime runs.[34] To increase ridership, the San Francisco and North Pacific Railroad company established a modest resort on the eastern shoreline of Tiburon Peninsula, known as El Campo.[35] Through the 1890s, the *Ukiah* transported weekend crowds of thousands to enjoy the resort's picnic grounds, dance pavilion, and music performances, as well as

[27] Nance, "The Paddle Steamer *Eureka*," 54-60.
[28] Nance, "The Paddle Steamer *Eureka*," 54-60; Christopher Edwards, SAFR Park Ranger, "*Eureka* HSR – 50% Draft – Review Comments – Supplemental Information," 2021.
[29] Nance, "The Paddle Steamer *Eureka*," 54-60.
[30] "A Magnificent Steamer," *Ukiah Daily Journal*; "A Fine Ferry Boat," *San Francisco Chronicle*, December 28, 1890, 18.
[31] "A Magnificent Steamer," *Ukiah Daily Journal*.
[32] "Trial Trip of the *Ukiah*," *San Francisco Call*, December 28, 1890, 7.
[33] Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 12; George H. Harlan and Clement Fisher, *Of Walking Beams and Paddle Wheels*; *A Chronicle of San Francisco Bay Ferryboats* (San Francisco: Bay Books, 1951) 89; United States Patent Office, *Annual Report of the Commissioner of Patents for the Year 1895* (Washington, D.C., Government Publishing Office, 1895) 665.
[34] Lynn Cullivan, "1890-1990 *Eureka*, A Centennial Retrospective," *Sea Letter* (Journal of the National Maritime Museum Association), No. 42, Spring/Summer 1990, 31.
[35] "To El Campo," *San Francisco Call*, August 2, 1891, 1.

opportunities for fishing, bathing, and nature viewing.[36]

In 1898, Southern Pacific Railroad established the "paper" rail company California Northwestern Railway.[37] In 1906 the Southern Pacific and the Atchison, Topeka & Santa Fe railroads acquired and merged several dozen regional rail lines in Northern California to establish the Northwestern Pacific Railroad. The San Francisco and North Pacific Railroad was bought by the (Southern Pacific owned) California Northwestern Railway as part of this merger, and in 1907 the *Ukiah* ceased direct service between San Francisco and Tiburon and instead began runs between San Francisco and Sausalito, the southern terminus of the new rail company's lines. At this time, the hurricane deck was modified to include passenger cabins, reflecting an increase in regular commuters as the residential neighborhoods of Marin County grew.[38]

The vessel's original two Flue Return Tubular coal-fired boilers were reconfigured to oil-fired boilers in 1906.[39] This change reflected broader twentieth-century shifts in regional, national and global energy paradigms in which oil largely replaced coal as fuel for steam-powered engines.

In October 1912, Northwestern Pacific Railroad initiated the process of removing the two oil-burning boilers that powered the *Ukiah* and replacing them with four Freeman Dryback oil-fired boilers.[40] In these boilers an oil flame was sprayed from a burner with steam atomization into the furnace.[41] Installation of the vessels new boilers was complete by 1914.

By 1915, the emerging popularity of private automobiles put pressure on the Northwestern Pacific Railroad company to provide automobile ferry service across the bay. Initially resistant to accommodating vehicles, which they surely perceived as a threat to the dominance of rail travel, the company set a limit of just four private vehicles for each bay crossing aboard the *Ukiah*.[42] Marin County boosters saw the lack of auto ferry service as a hindrance to the development of the county's small towns that were steadily incorporating in the first decades of the twentieth century, and pressured Northwestern Pacific to adapt existing ferries or construct new ferries to provide auto service. In response to these pressures, the main deck of the *Ukiah* was built up to rail-track level to accommodate autos, and in 1915 began running auto-only trips between San Francisco and Sausalito on Sundays, holidays, and on one daily early-morning run.[43]

In 1917, shortly after the United States entered World War I, the United States Railroad Administration formed to nationalize the lines of existing railroad companies, including affiliated ferries, for the war effort. The *Ukiah* spent the years between 1917 and 1920 under control of the United States Railroad Administration, primarily hauling heavily loaded boxcars out of Richmond, California.[44] By 1920, the vessel was extensively damaged from hard use, and Northwestern Pacific applied for and received federal funds for repairs. The *Ukiah* entered the Oakland shipyard of Southern Pacific, the parent company of Northwestern Pacific, and underwent the significant rebuild that transformed her into the *Eureka*.

[36] "Sunday at El Campo," *San Francisco Call*, April 13, 1896, 9.
[37] Christopher Edwards, SAFR Park Ranger, "*Eureka* HSR – 75% Draft – Review Comments – Supplemental Information," 2022; Online Archive of California, "California Northwestern Railway Records," collection guide accessed March 8, 2022 at https://oac.cdlib.org/findaid/ark:/13030/c80p13cz/.
[38] Christopher Edwards, "*Eureka*, Physical Chronology of the Vessel," 2020; Cullivan, "1890-1990 *Eureka*, A Centennial Retrospective," 31.
[39] Edwards, "*Eureka* HSR – 50% Draft – Review Comments – Supplemental Information," 2021.
[40] Christopher Edwards, "Documentation of *Ukiah* New Boiler Installation in 1914," 2020, 1.
[41] Edwards, "*Eureka* HSR – 75% Draft – Review Comments."
[42] "N. W. P. to Facilitate Auto Transportation," *Santa Rosa Press Democrat*, August 8, 1915, 2.
[43] "N. W. P. to Facilitate Auto Transportation," *Santa Rosa Press Democrat*.
[44] Cullivan, "1890-1990 *Eureka*, A Centennial Retrospective," 31.

Eureka under construction in Oakland, ca. 1921 (SFPL Historical Photograph Collection, ID no. AAH-0213)

EUREKA ERA (1922-PRESENT)

The *Ukiah* spent two years at Southern Pacific's Oakland shipyard, where a workforce of two hundred men overseen by assistant yard superintendent Charles Green stripped the vessel of all of her original components with the exception of the keel, four frames (king posts), and the walking beam engine.[45] The wooden A-frame which supported the engine was replaced with one of riveted steel, and the existing paddlewheels were replaced with similarly sized 27' paddlewheels. The new design reconstructed and lengthened the hull with ninety percent new lumber and enlarged the main deck to slightly over 299' length overall with a 78' beam at the deck.[46]

Construction was complete by March 1922 and the vessel, still bearing the U.S. Department of Commerce record number assigned to the *Ukiah*, was renamed the *Eureka*, in honor of the Northwestern Pacific's recently completed northern terminus.[47] The *Eureka* was placed into service between the Ferry Building in San Francisco and the Northwestern Pacific railroad station in Sausalito. As announced in the press on March 29, 1922, the enclosed passenger deck of the *Eureka* (described as the "saloon deck") included seating for 1,000 people, as well as a smoking room, restaurant, news stand, and "retiring" rooms. The enclosed main deck provided space for 120 automobiles, along with removable seating, which, when in use, brought the maximum passenger number up to 3,500.[48]

Based on architectural plans of the main and passenger decks drawn in 1922 and 1926, the arrangement of the passenger deck restaurant included two bracket-shaped nested bar tables, with thirty-two seats at the outer bar and twenty seats at the inner bar, both served by a central aisle.[49] In the middle of the nested bar tables was a central serving table. Along the starboard side, a side table area included three circular tables with four seats each. Along the wall left of the galley door was a small coffee service table. Inside the galley were an icebox, a steam table, a range, and a sink.[50]

Both large bathrooms on the passenger deck atop the paddlewheel boxes were labeled as women's bathrooms. Foyer spaces at these bathrooms were labeled "women's rest room" and fitted with benches at the outboard and aft walls. The forward ends of the paddlewheel box enclosures included a small men's bathroom at port and a news stand and enclosed smoking room at starboard, which extended all the way forward to the forward wall of the deckhouse. The area later used as a news stand, aft of the engine casing, was fitted with passenger seats.[51] In 1928, a women's smoking room was added, believed through research to have been located on the starboard side of the passenger deck, aft of the restroom currently labeled for women.[52] At the main deck, movable bench seats were

[45] Mark R. Porter, "Addendum to the Historic American Engineering Record, Ferry *Eureka*, HAER No. CA-59," San Francisco, CA, 2001, 5; Cullivan, "1890-1990 *Eureka*, A Centennial Retrospective," 31; Edwards, "Supplemental Information," 2021.
[46] Nance, "The Paddle Steamer *Eureka*," 52.
[47] Haller, Eureka *National Register Form*, Section 8, Page 3.

[48] Cullivan, "1890-1990 *Eureka*, A Centennial Retrospective," 32.
[49] Edwards, "*Eureka* Physical Chronology," 15-16.
[50] Edwards, "*Eureka* Physical Chronology," 15-16.
[51] Edwards, "*Eureka* Physical Chronology," 15-16; Edwards, "*Eureka* HSR – 75% Draft – Review Comments."
[52] Edwards, "*Eureka* Physical Chronology," 16; Edwards, "*Eureka* HSR – 50% Draft – Review Comments."

located along the outboard walls. The forward end of the paddle wheel boxes included men's bathrooms.[53]

The *Eureka* was the largest of Northwestern Pacific's ferries and served as an integral link in a modern transportation network. The vessel carried an average of 2,200 passengers per crossing on the most popular departures, the 7:30am from Sausalito to San Francisco and the 5:15pm from San Francisco to Sausalito.[54] The crossing took slightly over thirty minutes on average, and most passengers transferred in Sausalito to electric interurban trains which brought them to and from the Marin County suburbs of San Rafael, San Anselmo, and Fairfax.

The vessel was operated by a crew of between thirteen and fifteen men.[55] Crews worked eight-hour shifts and did not live aboard, and at times the *Eureka* had three separate crews. The captain had overall command of the vessel and was responsible for its safe operation. The captain steered the boat and worked closely with the first mate, who also steered the vessel; generally, the captain made landings and departures at San Francisco with the first mate handling these tasks in Sausalito. The second mate controlled the main deck, docking and tying up the boat and managing the gangplanks. The second mate was assisted by six deckhands, who also cleaned, completed general maintenance, and assisted with general daily operations.[56]

Below deck, the chief engineer oversaw the operation and maintenance of the ferry's mechanical systems with the aid of the assistant engineer. Two firemen were responsible for starting, adjusting, and extinguishing the boiler fires, and the oilers checked oil levels, greased fittings and checked the condition of bearings and pumps. A watchman also patrolled the ship for general hazards both on and off board.[57]

[53] Edwards, "*Eureka* Physical Chronology," 15-16.
[54] Cullivan, "1890-1990 *Eureka*, A Centennial Retrospective," 32.
[55] Cullivan, "1890-1990 *Eureka*, A Centennial Retrospective," 33.
[56] Cullivan, "1890-1990 *Eureka*, A Centennial Retrospective," 33; Porter, "Addendum, Ferry *Eureka* HAER," 13, 24.
[57] Cullivan, "1890-1990 Eureka, A Centennial Retrospective," 33.

A porter worked at the passenger deck, generally assisting passengers as needed with boarding, loading, seating and similar. Also at the passenger deck were servers at the ship's restaurant and later snack bar, from whom hungry passengers could order coffee, coffee cake and doughnuts, or heartier fare such as oatmeal, ham and eggs, or even snails.[58]

In 1930, the San Francisco Ferry Building was said to be second only to London's Charing Cross Station as the busiest passenger terminal in the world. That year, the various ferries of the Southern Pacific fleet, of which the *Eureka* was included, carried over forty million passengers and six million automobiles around the bay.[59] However, the success of the passenger and automobile ferries contributed to their eventual demise: as regional rail travel historian Harre Demoro describes it, "the ferries wrote [their] own *finis* - they built commuter communities large enough to support bridges," namely the San Francisco-Oakland Bay Bridge, completed in 1936, and the Golden Gate Bridge, completed in 1937.[60]

Ferry services curtailed their schedules due to decreased ridership in the second half of the 1930s, but ridership continued to decrease to a degree that by 1941, Northwestern Pacific terminated ferry service between San Francisco and Sausalito. The last day of Marin County ferry service was March 1, 1941, and *Eureka* had the distinction of making the very last run.[61] A rowdy celebratory crowd of more than 2,500 passengers made the final journey, free of charge.[62] Passengers were treated to the music of a four-piece orchestra, and, upon disembarking in Sausalito, passengers were met by Southern Pacific patrolmen who relieved them of many of the "souvenirs" they attempted to

[58] Porter, "Addendum, Ferry *Eureka* HAER," 13, 26.
[59] Haller, Eureka *National Register Form*, Section 8, Page 4.
[60] Harre W. Demoro, *Electric Railway Pioneer: Commuting on the Northwestern Pacific, 1903-1941* (Glendale, California: Interurban Press, 1983) 63; quoted in Haller, Eureka *National Register Form*, Section 8, Page 4.
[61] Haller, Eureka *National Register Form*, Section 8, Page 4.
[62] "A Ferry Bids Farewell to its Old Friends," *San Francisco Chronicle*, March 2, 1941, 70.

Celebrants on the final scheduled ferry passage of the Eureka, 1941 (SFPL Historical Photograph Collection, ID no. AAH-0216)

Eureka arriving San Francisco with passengers and freight, 1953 (SAFR, Catalog ID no. SAFR 21374)

take home from the trip.

Immediately after its ceremonial last passage to Sausalito, Southern Pacific placed the *Eureka* into service between the San Francisco Ferry Building and the Oakland Mole, transporting passengers to and from the company's cross-country rail terminal.[63] The main deck no longer carried automobiles, but instead held passengers' luggage and other Southern Pacific freight. When the United States entered World War II in December 1941, the *Eureka* was called into service again, moving shipyard workers between San Francisco and Richmond, and troops from Camp Stoneman in Pittsburg, California to the Port of Embarkation at Fort Mason.[64] The vessel was painted gray during this time, and fitted with stanchions and cables to deflect mines.[65]

After the war ended, Southern Pacific placed the *Eureka* back into service between Oakland and the San Francisco Ferry Building. During this time, the *Eureka* became one of the growing number of civilian vessels on San Francisco Bay to be fitted with radar.[66] Although the vessel was extensively refitted in 1954, ridership continued its downward trend, especially as airplane travel eclipsed rail travel for inter-regional and cross-country trips.[67] Tourists, sightseers, and nostalgia seekers sometimes took the cross-bay trip, but the vessel was no longer a vital part of the area's commuting network. After February 10, 1957, when one of the *Eureka*'s crankpins snapped, Southern Pacific elected to take the vessel out of service rather than complete the relatively simple repair.[68] The following year, the last cross-bay ferry run was made by the ferry *San Leandro*, on July 30, 1958.[69]

CALIFORNIA STATE OWNERSHIP ERA (1957-1977)

In the early 1940s, mariner and sailing ship enthusiast Karl Kortum began to muster public support for the establishment of a museum in San Francisco dedicated to the maritime history of the Pacific. After almost ten years of planning, the San Francisco Maritime Museum opened to the public in 1951, with Kortum as director. In 1957, a California state park unit named San Francisco Maritime

[63] "A Ferry Bids Farewell to its Old Friends," *San Francisco Chronicle*.
[64] "The *Eureka* Ferry Rammed by Liner in Heavy Bay Fog," *San Francisco Chronicle*, January 13, 1943, 15; Porter, HAER, Ferry *Eureka*, 25.
[65] Porter, "Addendum, Ferry *Eureka* HAER," 13, 25.
[66] Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," 17.
[67] Cullivan, "1890-1990 *Eureka*, A Centennial Retrospective," 32.
[68] Haller, Eureka *National Register Form*, Section 8, Page 5.
[69] "A Sad Farewell to an Old Friend," *San Francisco Chronicle*, July 30, 1958, 1.

State Historic Park was established to display historic ships at Hyde Street Pier.

Several months after the *Eureka* was taken out of service, Southern Pacific offered to donate the vessel to the San Francisco Maritime Museum. Also on offer was another surplus Southern Pacific ferry, the *Berkeley*, which was constructed in 1898 with a steel hull, and retained a richly ornate passenger deck with original stained-glass windows.[70] Despite a stated understanding of the potential future maintenance costs of a wood hulled vessel, Karl Kortum selected the *Eureka*, primarily because of the historic significance of the vessel's walking beam engine, and also because of the *Eureka'*s big side paddlewheels, which he believed were more evocative of the great age of ferryboat travel than the simple propeller on the *Berkeley*. Kortum recognized the scale of undertaking restoration of the *Eureka*, both in the array of repairs and the cost for completing them, and initially imagined that the *Eureka*'s walking beam engine may need to be preserved as a stand-alone display in a waterfront location such as the Haslett Warehouse or the Fontana Building (no longer extant), going as far as to sketch out ideas for its interpretive arrangement.

Reflecting the scope and cost of restoration, the San Francisco Maritime Museum accepted the donation of the *Eureka* with the understanding that the vessel would be turned over to the State of California to join the other state-owned vessels that would be displayed at the new San Francisco Maritime State Historic Park at Hyde Street Pier. However, before that could be arranged, the San Francisco Maritime Museum owned the *Eureka* for more than a year, and, when Southern Pacific asked that the vessel be removed from the Oakland Mole, Maritime Museum staff and volunteers carefully transported the vessel to an abandoned ferry slip at the Richmond-San Rafael ferry terminal.[71] Title of the vessel was transferred to the State of California in 1958.

Restoration of the *Eureka* took three years and was supervised by Karl Kortum and Harry Dring. Work was financed by the tideland oil revenues managed and distributed by the State Division of Beaches and Parks.[72] An initial phase of work largely confined to the hull and paddlewheels was completed at Bethlehem Shipyard in 1960, while additional work was completed between 1960 and 1963 at the Oakland Dock and Warehouse Co., where the *Wapama, C. A. Thayer,* and the *Alma* concurrently underwent restoration in preparation for joining the San Francisco Maritime State Historic Park.[73]

Some of the major components of the restoration that took place while the vessel was in drydock in Oakland included installation of an electric jacking motor for turning over the main engine; modifications to the restrooms and plumbing to enable visitors and staff to use of the historic restrooms; and renewal of the roofing and floor coverings.[74] In 1962, a collection of antique automobiles was placed on the main deck as part of an interpretive program to help people imagine what the vessel was like when it served as an automobile ferry. Additional general preparations were made to enable visitors to walk on all three of the vessel's decks and visit the engine room.[75] As repairs were drawing to a close and the outside of the house was being repainted, Harry Dring publicly asked old-time Marin commuters to search their memories for the colors of the Northwestern Pacific Railroad emblems which historically graced the sides of the vessel above the paddlewheels.[76]

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[70] Karl Kortum, "Why I Picked the *Eureka*," *Sea Letter* (Journal of the National Maritime Museum Association), No. 42, Spring/Summer 1990, 34.

[71] Kortum, "Why I Picked the *Eureka*," 34.

[72] "Jack Foisie, "Rebirth of an Old Ship," *San Francisco Chronicle*, September 23, 1963, no page, clipping in the San Francisco Maritime Museum subject file, San Francisco Public Library, History Center.

[73] Tri Coastal Marine Inc., Draft Historic Structure Report for *Eureka*, 19; "Schooner Restoration Speeded," *San Francisco Examiner*, November 9, 1960, 27.

[74] Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," 19.

[75] Haller, Eureka *National Register Form*, Section 8, Page 5.

[76] "Ferryboat Emblems," *San Francisco Chronicle*, June 9, 1963, 31.

Ford Model A being loaded on to the Eureka, 1962 (SAFR, Catalog ID no. SAFR 09318)

The *Eureka* made passage from Oakland to Hyde Street Pier on October 2, 1963, and was the centerpiece of the dedication of the San Francisco Maritime State Historic Park on October 6, 1963, officiated by Governor Edmund G. Brown.[77] The new state park became fully operational and officially opened to the public on January 1, 1964.[78] The *Eureka* was one of three ships outfitted with permanent gangways, along with the steam schooner *Wapama* and the sailing schooner *C. A. Thayer,* that could be boarded and toured by the public. At the time of the park's opening, a portion of the main deck of the *Eureka* was partitioned off from visitor foot traffic and was in use as a rigging loft, where a crew worked on building shrouds to rerig the *Thayer,* moored directly across the pier.[79] At the time of its opening, the collection of historic ships at San Francisco Maritime State Historic Park was the only such museum display in the country with the exception of Mystic Seaport in Mystic, Connecticut.[80]

In the face of perpetually limited funding, San Francisco Maritime State Historic Park personnel continued to provide scheduled maintenance to the *Eureka* in the years after it opened to the public at Hyde Street Pier. Abovedeck work, including window repairs and replacement, some deck repair, and restoration of one of the vessel's pilothouses, was completed largely by San Francisco Maritime State Historic Park maintenance personnel, while hull maintenance was addressed during drydock periods in 1965 and 1973.[81] In 1973, Allen W. Welts, historian with the California Department of Parks and Recreation, prepared a successful National Register of Historic Places Inventory Nomination Form for the *Eureka*. In addition to a description of the vessel and information about its construction history and working life, the nomination notes that the "vessel enjoys constant maintenance by qualified shipwrights, deck hands, interpretive and administrative personnel."[82]

NATIONAL PARK SERVICE OWNERSHIP ERA (1977-PRESENT)

In 1977 the San Francisco Maritime State Historic Park and its ships were transferred to the National Park Service as part of the newly established Golden Gate National Recreation Area.[83] In 1983, *Eureka* oversight was transferred to the Maritime Unit of the Golden Gate National Recreation Area. In 1984, National Park Service Park Ranger Steven Haller prepared an updated National Register of Historic Places Nomination Form for the *Eureka*, and the vessel was designated as a National Historic Landmark on February 4, 1985.[84] In 1988, San Francisco Maritime National Historical Park became a separate administrative unit of the National Park Service. Today, under the purview

[77] Jack Foisie, "Rebirth of an Old Ship," *San Francisco Chronicle*.
[78] "Maritime Park Opening Slated," (San Pedro) *News-Pilot*, December 26, 1963, 2.
[79] "The Museum Ships of Hyde Street," *San Francisco Chronicle*, October 6, 1963, 104.
[80] Untitled clipping. *Sunset Magazine*, October 1963, 18, clipping in the San Francisco Maritime Museum subject file, San Francisco Public Library, History Center.

[81] Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," 20-21.
[82] Allen W. Welts, California Department of Parks and Recreation, Eureka *National Register of Historic Places Inventory Nomination Form*, San Francisco, CA, 1973, 2.
[83] Haller, Eureka *National Register Form*, Section 8, Page 5.
[84] National Park Service, "National Historic Landmarks," website of the National Park Service, accessed October 29, 2021 at https://www.nps.gov/subjects/nationalhistoriclandmarks/list-of-nhls-by-state.htm

of the National Park Service, the vessel along with others at Hyde Street Pier is visited by an average of 200,000 persons a year.

Since coming under National Park Service ownership, the *Eureka* has continued to undergo cyclical maintenance and restoration through periods of drydocking. In 1978 the vessel entered drydock for maintenance including removal and replacement of plywood sheathing, bottom painting, exterior painting, miscellaneous routine items, and repair to the foundation of the steel paddle box on the port side and portions of the rubrail and steel chafing plate.[85] Another period of drydock in 1984 included hull cleaning, removing and replacing plywood sheathing for hull plank inspection, repairs to copper sheathing, caulking of the hull, doubler on the bottom, and repairs to sea chest openings, as well as replacing beams and stringers in the way of the lifeboat and davits on the starboard quarter, and replacing 920 square feet of canvas covered tongue and groove decking.[86] Scope of work during drydocking in 1993 included exterior hull repair with specified repairs and removals; refastening below the water line with specified removal and replacement of deteriorated hull-planking spikes; renewal to the rubrail, deck beam, and spring beam; hull cleaning and painting, with surface preparation and coating of hull; repairs to the main deck; manufacture and installation of replacement bearing beams; opening and inspecting designated sea suction valves; refastening planking to the hull; support beam repair; copper removal from hull and keel and installation of replacement; deck repairs to the fan ends (aprons) and support structure due to extensive deterioration; and upgrades to electrical services.[87]

In 1999, the *Eureka* entered drydock for a two-year period, with a scope of work including hull cleaning; inspection and replacement of damaged planking; replacement of damaged copper sheathing; repair of main deck and rotten wood in hull; cleaning and overhaul of sea suction valves including sea strainers, block and check valves; and painting the hull. The Southern Pacific restaurant was modified by park staff in the late 1990s or early 2000s.[88] Additional work included fabrication of several dozen new windows due to excessive rot; installation of two hawse pipes; restoration of both paddlewheels and paddlewheel houses; and replacement of sheathing fore and aft on the port and starboard sides of the main and passenger decks.[89]

Additional smaller undertakings during the period of National Park Service ownership that have not required drydock periods have included repair to some bench seating on the passenger deck, reroofing, smokestack and walking beam repairs (including refabrication of the smokestack cap and fidley apron), painting, deck repair, electrical and lighting repairs, and installation of the gangway and access ramp at Hyde Street Pier. The *Eureka* has not been placed in drydock for hull maintenance or repair since 2000. Existing material conditions are detailed elsewhere in this report.

[85] Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," 20-21.

[86] San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 005.

[87] San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 18

[88] Edwards, "*Eureka* HSR – 75% Draft – Review Comments."

[89] San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 40 and 43.

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Section Four

Chronology of Development and Use

This chronology presents information from a variety of sources, including the National Register of Historic Places Inventory Nomination Form for the *Eureka*, prepared by California Department of Parks and Recreation historian Allen W. Welts in 1973; an updated National Register of Historic Places Inventory Nomination Form for the *Eureka*, prepared by National Park Service Park Ranger Stephen Haller in 1984; Addendum to Historic American Engineering Record (HAER) recordation for the *Eureka* prepared by historian Marc R. Porter in 2001; a Draft Historic Structure Report for *Eureka* completed by Tri-Coastal Marine, Inc. in 1990; a physical chronology of the vessel and of the installation of oil-burning boilers, prepared by SAFR Park Ranger Chris Edwards in 2020; Preliminary Engineering Report - Ferryboat *Eureka* Critical Systems, completed by Mott MacDonald in 2020; Final Task Order Report on the Structural Condition the Ferry *Eureka*, completed by Anthony Guild in 2020 and again in 2021; and information compiled by SAFR from several work logs in 2021. ARG has completed additional archival research, secondary source research, and site work as needed to further develop the chronology. A comprehensive chronology with citations is included in Appendix A.

DATE	EVENT
1847	Pioneering businessman Alexander Leidesdorff was an early innovator in ferry service, operated a small steam ferry between San Francisco, the East Bay, and Sacramento.
1848	Gold was discovered at Sutter's Mill in the foothills of the Sierra Nevada Mountains, which initiated a massive population influx in the Bay Area of California and a coincident need for ferry service around the San Francisco Bay.
1850	*Kangaroo* becomes the first steamboat to make regular ferry crossings in the Bay Area, providing service between Oakland and San Francisco.
1868	Regular ferry service was established to Marin County when the *Princess* began running between Sausalito and Meiggs' Wharf, near the current location of Powell and Francisco streets in San Francisco.
1869	San Francisco and North Pacific Railroad was bought by Peter Donohue, and first tracks were constructed with southern terminus in Petaluma, California.
1884	San Francisco and North Pacific Railroad established southern terminus and ferry terminal at Tiburon, California. Peter Donahue commissioned master shipbuilder Captain Patrick H. Tiernan to design his first vessel for that company, the double-ended ferry *Tiburon*.
1890	San Francisco and North Pacific Railroad commissioned Captain Patrick H. Tiernan for the construction of the ferryboat *Ukiah*, later renamed *Eureka*, to transport rail cars, freight and passengers between the San Francisco Ferry Building and its southern terminus ferry terminal in Tiburon, California. The *Ukiah* was Tiernan's last commission before retirement. Vessel was launched in May 1890 and began regular service in December 1890.

Chronology of Development and Use

Ca. 1890-1905	*Ukiah* transported weekend crowds of thousands to the modest resort El Campo on the eastern shoreline of Tiburon Peninsula. The San Francisco and North Pacific Coast Railway company established El Campo to increase ferry ridership, and amenities included a dance pavilion, merry-go-round, bowling alley, fishing pier, shooting gallery and picnic grounds.
Ca. 1900	Nearly thirty major ferry routes operated on the San Francisco Bay, most of which were operated by or adjunct to the railroad lines that they served.
1906	The Southern Pacific and the Atchison, Topeka & Santa Fe railroads acquired and merged several dozen regional rail lines in Northern California to establish the Northwestern Pacific Railroad. The San Francisco and North Pacific Coast Railway was part of this merger.
1907	*Ukiah* ceased direct service between San Francisco and Tiburon and instead began runs between San Francisco and Sausalito, the southern terminus of the Northwestern Pacific Railroad lines. Around this time, original coal burning boilers were converted to oil burning boilers, and the hurricane deck of the *Ukiah* was modified to include passenger cabins, reflecting an increase in regular commuters as the residential neighborhoods of Marin County grew.
1914	*Ukiah*'s two converted oil-fired boilers were removed and replaced with four oil-fired boilers.
1915	Faced with the emerging popularity of private automobiles, Northwestern Pacific Railroad, though initially resistant to accommodating vehicles, began to allow limited numbers of private automobiles on the *Ukiah*. Marin County boosters saw the lack of auto ferry service as a hindrance to the development of the county's small towns that were steadily incorporating in the first decades of the twentieth century, and pressured Northwestern Pacific to adapt existing ferries or construct new ferries to provide auto service. In response to these pressures, the main deck of the *Ukiah* was built up to rail-track level to accommodate autos, and in 1915 began running auto-only trips between San Francisco and Sausalito on Sundays, holidays, and on one daily early-morning run.
1917	United States Railroad Administration formed to nationalize the lines of existing railroad companies, including affiliated ferries, for the war effort.
1917-1920	*Ukiah was* under control of the United States Railroad Administration, primarily hauling heavily loaded boxcars out of Richmond, California.
1920-1922	Northwestern Pacific Railroad applied for and received federal funds to have the *Ukiah* repaired after extensive damaged incurred during hard use by the Railroad Administration. The *Ukiah* entered the Oakland shipyard of Southern Pacific, the parent company of Northwestern Pacific, and underwent a significant rebuild that transformed her into the *Eureka*. The reconfigured vessel could transport 120 automobiles and 1,000 passengers, and up to 3,500 passengers with no automobiles aboard. The *Eureka* went into service between the San Francisco Ferry Building and Sausalito in March 1922.

Chronology of Development and Use

Ca. 1922	Following an accident on the ferry *Sausalito* wherein the black color of the walking beam was blamed for overlooked forging flaws, white replaced black as the customary paint color for walking beams, including on the rebuilt *Eureka*.
1927	Carquinez Bridge opened connecting Contra Costa County and Solano County.
1930	San Francisco Ferry Building was said to be second only to London's Charing Cross Station as the busiest passenger terminal in the world. In 1930, the various ferries of the Southern Pacific fleet, of which the *Eureka* was included, carried over forty million passengers and six million automobiles around the bay.
1936	San Francisco-Oakland Bay Bridge opened connecting Oakland and San Francisco.
1937	Golden Gate Bridge opened connecting Marin County and San Francisco.
1941	Northwestern Pacific terminated ferry service between San Francisco and Sausalito. The last day of Marin County ferry service was March 1, 1941, and *Eureka* made the last run. Immediately after its last passage, Southern Pacific placed the *Eureka* into service between the San Francisco Ferry Building and the Oakland Mole, transporting passengers to and from the company's cross-country rail terminal. The main deck no longer carried automobiles, but instead held passengers' luggage and other Southern Pacific freight.
1941-1945	During World War II, the *Eureka* moved shipyard workers between San Francisco and Richmond, and troops from Camp Stoneman in Pittsburg, California to the Port of Embarkation at Fort Mason, San Francisco. The vessel was painted gray and fitted with stanchions and cables to deflect mines.
1945	After World War II, Southern Pacific returned *Eureka* to service between the San Francisco Ferry Building and the Oakland Mole.
1951	San Francisco Maritime Museum opened to the public on May 27, 1951.
1954	*Eureka* underwent extensive refitting.
1957	Within the context of steadily diminishing ridership, *Eureka* was retired from service after one of the vessel's crankpins snapped on February 10, 1957.
1957	California state park unit named San Francisco Maritime State Historic Park was established to display historic ships at Hyde Street Pier.

Chronology of Development and Use

1957	Southern Pacific offered to donate the *Eureka* to the San Francisco Maritime Museum. The donation was accepted with the understanding that the vessel would be turned over to the State of California to join the state-owned vessels that would be displayed at the new San Francisco Maritime State Historic Park at Hyde Street Pier. Following the donation, the staff of San Francisco Maritime Museum transported the vessel to an abandoned ferry slip at the Richmond-San Rafael ferry terminal.
1958	Last cross-bay ferry run was made by the ferry *San Leandro*, on July 30, 1958.
1958	Title of the *Eureka* was transferred to the State of California.
1958-1977	*Eureka* was owned by State of California.
1960-1963	*Eureka* underwent three years of restoration to prepare the vessel for use as a museum display. Collection of antique automobiles was added to the main deck for interpretive purposes.
October 1963	*Eureka* was moved to its permanent berth at Hyde Street Pier for the dedication of the San Francisco Maritime State Historic Park.
January 1964	San Francisco Maritime State Historic Park officially opened to the public. The *Eureka* was outfitted with permanent gangways and could be boarded and toured by the public.
Ca. 1968	Newly established ferry service began between Tiburon and San Francisco.
1970	Newly established ferry service began between Sausalito and San Francisco.
1973	*Eureka* was listed on the National Register of Historic Places based on a nomination prepared by Allen W. Welts, historian with the California Department of Parks and Recreation.
1976	Newly established ferry service began between Larkspur and San Francisco.
1977	The San Francisco Maritime State Historic Park and all of its ships including the *Eureka* came under management of the Golden Gate National Recreation Area, a newly established national park.
1977-present	*Eureka* is owned and overseen by the National Park Service.
1983	*Eureka* oversight was transferred to Maritime Unit of the Golden Gate National Recreation Area.
1984	National Park Service Park Ranger Steven Haller prepared an updated National Register of Historic Places Nomination Form for the *Eureka*.
1985	*Eureka* designated as a National Historic Landmark on February 4, 1985.

1986	Newly established ferry service began between Vallejo and San Francisco.
June 1988	San Francisco Maritime National Historical Park became a separate administrative unit of the National Park Service.
1989	Following damage to the San Francisco-Oakland Bay Bridge in the Loma Prieta Earthquake, newly established ferry service began between Oakland and San Francisco.
Present	The vessel is visited by an average of 200,000 persons a year.

CHRONOLOGY OF PHYSICAL CONSTRUCTION

This table lists substantial changes to the physical material of the Eureka.

DATE	EVENT
October 1889	Keel of *Ukiah* was laid down at North Pacific Railway Yard in Tiburon, California. Vessel was designed by Patrick H. Tiernan and built by John Dickie. The vessel was fitted with a walking beam engine manufactured at Fulton Iron Works in San Francisco.
1890	*Ukiah* went into service.
Ca. 1890s	Some time after the vessel was launched, the original manual steering system that the *Ukiah* was constructed with was replaced by two double cylinder steering engines, designed by master mechanic John Bonner.
October 18, 1900	*Ukiah* ran aground on Angel Island en route to San Francisco from Tiburon in a heavy nighttime fog. Damage was localized to a broken rudder and badly strained plates in the bow, and the vessel spent two weeks in drydock in Tiburon for repair.
1906	Original coal fired boilers were converted to oil-fired boilers.
Ca. 1907	Hurricane deck of the *Ukiah* was modified to include passenger cabins.
April 16, 1907	*Ukiah* sank while docked in San Francisco at the Lombard Street wharf. Divers inspected the hull, sealed the portholes, pumped out, and towed the vessel to the Southern Pacific yard in Oakland for repairs.
October 1911	Fractured cylinder head at the main engine replaced with new cylinder head.

Chronology of Development and Use

February 1912	Hull inspection report included the following information about the *Ukiah:* ▪ Two wooden watertight bulkheads; ▪ Two decks with permanent stairways; ▪ Two anchors with chain cable; ▪ Double steering gear (one set at each end of vessel) inclusive of wire tiller ropes and iron rod and chain; ▪ Wire bell pulls for engine room signals, and communication/voice tubes for communication between pilot houses and the engine room; and ▪ Four lifeboats.
August 15, 1912	General repairs and maintenance authorized for the *Ukiah*.
October 23, 1912	Four new boilers authorized to be constructed for the *Ukiah*. Boilers constructed by Seattle Construction and Dry Dock Company.
March 10, 1913	Construction of new boilers for *Ukiah* began.
March 12, 1913	Nineteen-day period of general repair and maintenance began for *Ukiah*.
March-April 1914	Fifty-one-day period of service and repair, including installation of four new boilers and related work including renewal keelsons and other timber, special support for tracks carrying cars over the boilers, and renewal of fire and circulating pumps and piping.
June 1915	Unspecified project related to compartments.
February-April 1916	Restaurant added to the hurricane deck of the *Ukiah*, as part of an effort to better accommodate automobile ferry users. New construction included a restaurant, ladies' cabin, smoking room, and additional toilets
March-April 1916	Work done on decking.
March 17, 1916	Project authorized for new feed water heaters for *Ukiah*.
August 30, 1916	Addition of new stairway, location unknown.
January 1917	Carbide lamps purchased for onboard use.
February 1917	Stairway added at an unknown location, may be duplicate record for August 1916 stair.
June 1917	Two fireroom ventilators added to the vessel.

Chronology of Development and Use

April 1918	Feedwater heaters added to the engine room.
July 1919	Signs added onboard, no further information. Cost was $43.97.
April 1920	Engine order telegraphs added to the pilot houses.
June 1920	Oil meter to measure fuel consumption added to the engine room. Unknown if this was a replacement or new equipment. Cost was $72.37
July 1920	Handrails added to vessels' gangplanks. Cost was $22.24
January 29, 1921	Lights added to the vessel. Unknown if these were replacements or new equipment. Cost was $156.12.
April 17, 1921	Blueprint of the *Ukiah* showed general machinery layout, with two fuel tanks (one each directly aft of boilers 3 and 4) and three water tanks in the compartment immediately aft of the engine room.
1921-1922	Following several years of hard use during World War I under the United States Railway Administration transporting railcars loaded with munitions, *Ukiah* was one of two Northwestern Pacific ferries chosen to be rebuilt. Work was undertaken at the Southern Pacific Shipyard in Oakland and around 200 men were involved in the rebuilding effort. Scope of work was described as such: "Complete reconstruction of steamer *Ukiah*, freight car and automobile transfer boat, into automobile and passenger carrying ferry steamer; name changed to *Eureka*. Tracks and entire housing removed; complete reconstruction and lengthening of hull (90% new timber used); wooden engine keelsons and gallows frame replaced with steel; engines, boilers and auxiliaries repaired and re-installed; hull recovered and caulked; superstructure and cabins entirely new construction; large restaurant facilities provided on saloon deck. Changes and additions necessary to provide facilities for the increasing automobile and passenger business. Renewal of hull, frames and other timbers requested by United States Local Steamboat Inspectors." On March 11, 1922, rebuilt *Eureka* made a trial trip and recorded the following physical specifications: ▪ Official Number: 25279 ▪ Rig: Side-Wheel Steamer ▪ Gross Tonnage: 2,420.00 ▪ Net Tonnage: 1,500.00 ▪ Length: 299' 6" ▪ Depth: 15' 7"

	Engine specifications were as follows: ▪ Cylinder Diameter: 65 inches ▪ Stroke: 12 feet ▪ Gauge Pressure: 55psi ▪ Vacuum: 27.5 inches ▪ RPM: 20.5 ▪ Spring: 24 Total Indicated Horsepower: 1844.6
Ca. 1922-1926	Photographic evidence shows that sometime during the years 1922-1926, the jackstaffs originally mounted on either side of the main deck, on both ends of the vessel, were removed and replaced with a single jackstaff mounted on centerline at each end of the passenger deck.
March 1923	1200-gallon water supply tank added to the vessel (may be potable water tank or a new feed tank).
August 1923	Pantograph gates added at main deck.
December 1923	Walking beam link pin broke and was repaired.
May 1924	Approved annual inspections and repairs included replacement of 869 sheets of "yellow metal" (copper), and one wooden main deck beam was replaced with a metal section where it passed through the engine's eccentric rods; approval document stated this replacement was ordered by U.S. Inspectors.
September 1924	Additional seating installed on the main deck, described as such: "Installation of seats on main deck, forward and aft, which will provide additional seating capacity for approximately 227 passengers, such seats being required for the heavy passenger trips. Seating capacity of Steamer *Eureka,* on main deck, was originally limited, on account of projected use of this boat for automobile service. Seats have been found insufficient to take care of the peak load of commuters, and weekend passenger travel. The additional seats will be of the same type as the others on the main deck, i.e., removable when desired to use the boat in exclusive automobile service."
February 1925	Approval for seasonal repairs included docking, cleaning, and painting hull, renewing yellow metal (copper) where necessary, and annual inspection.
December 1925	*Eureka* damaged in an accident. Paddlewheel shaft broke and was repaired.

January 1926	Steel outboard bearing beam added at the starboard side, replacied a wooden beam, believed to be the outboard support for one of the paddle wheels.
March 1926	Approval for seasonal repairs included docking, cleaning hull, renewal of approximately 1,000 sheets of yellow metal (copper), repairs to fender, boilers, engines, lavatory, restaurant and galley. Renewal of main deck sheathing and painting where necessary.
June-July 1926	Attachment between the walking beam and crank pin broke during regular service. New constructed walking beam installed at Moore Dry Dock Co. Parts of the main engine including main rod and cross head that form the connection from the piston rod to the walking beam were increased.
1927	Drydock at Moore Drydock Co. in Oakland. Celeron applied to copper sheathing.
February 1928	Approval for annual inspection by U. S. Inspectors included drydock to clean the hull, renew yellow metal (copper) and make general repairs.
August 1928	Women's smoking room added at passenger deck.
January 1929	Crack discovered on walking beam strap, vessel taken out of service for immediate repairs. Work also included general operating repairs, repairs to the paddlewheels, tube renewal in all boilers.
November 1929	Improved lighting installed.
January 19, 1932	*Eureka* collided with steam schooner *Katherine* in heavy fog near the Ferry Building; damage does not sink either vessel or cause any loss of life.
1933	Walking beam strap cracked.
1933	The vessel's original jet condenser which sat atop the bed plate immediately beneath the cylinder was replaced by a surface condenser positioned below and behind the valve gear.
1934	Starboard paddlewheel shaft broke at inboard face of inboard wheel flange.
September 19, 1936	*Eureka* was struck amidships on the starboard side by the ferryboat *Golden West*. *Eureka* was towed to Sausalito with severe damage to a 40' section of the starboard side.
Ca. 1936-1957	Oral history data indicates that sometime after 1936, large glass windows which separated the smoking room from the starboard side promenade on the passenger deck were removed. The swinging doors into the smoking room, which appear in construction drawings from 1922, were also removed.

August 1937	LUX firefighting system was installed. This was a carbon dioxide firefighting system for use aboard ships and was invented and patented by Walter Kidde and Company, Inc. Blueprints show two banks of gas cylinders along the aft bulkhead and piping running through the length and at several points athwart the engine/boiler room along the bilges. Most of this system was removed at some point in the vessel's museum period.
1941	*Eureka* completed last day of Marin County ferry service; was immediately reassigned to service between the San Francisco Ferry Building and the Oakland Mole, transporting Southern Pacific passengers to and from the company's cross-country rail terminal. Sometime after being placed in service on the Southern Pacific route between Oakland and San Francisco, the original restaurant at the forward end of the passenger deck was removed. Portions of the exterior of the vessel were repainted to read Southern Pacific. Some information exists to indicate that a smaller "snack bar" was installed behind the engine room casing bulkhead.
1941-1945	*Eureka* was painted grey and fitted with stanchions and cables to deflect mines. May have received radar during this period.
January 1943	*Eureka* was struck by incoming liner and sustained significant damage 55' back of the bow (no side reported). The ferry berthed at a slip at the Oakland Mole, where Southern Pacific officials reported repairs would cost around $25,000 and take several weeks.
Ca. 1948-1953	Radar may have been installed at the vessel during this time.
1953-1954	Eureka entered drydock on October 16, 1953 for repairs at Moore Dry Dock Company in Oakland, California. The work was completed on May 19, 1954. The total cost was more than $600,000. Repairs to engines and boilers were as follows: repairs to boilers and boiler valves; repairs to main engine crank, bearings and crank pin; repairs to crosshead; repairs to lower steam chest; repairs to condenser and replacement of 1,700 condenser tubes; repairs to main fire pump and circulator; repairs to two steering engines; repairs to the electric generator; and repairs to paddle wheels. Repairs to the hull were as follows: removed and replaced all copper sheathing between waterline and the turn of bilge, about 125' on each side of hull; removed hull planking in above areas and

	replaced; applied heavy coats of wood preservative to new wood; removed entire inside ceiling between boiler room and engine room bulkhead to staggered butts, reinstalled new as per original; painted all areas disturbed; furnished and drove in new galvanized grommeted spikes; on Oakland end refastened every plank port and starboard from waterline to keel; removed and replaced main deck pointer on Oakland end; removed and replaced deteriorated futtock timbers; installed twenty-six natural knees and thirty timber knees; and, replaced four 70' keelsons in engine room and boiler room and four boiler bearers 62' long. Additional repairs were as follows: repairs to rudder; repairs to main switchboard; replacement of some main deck sheathing with 1" x 4" clear cedar; renewal of steering sheaves and troughs; removal of entire tongue and groove engine room floor and replacement with new flooring; installed new angle bars, handrails and replaced approximately 10% of boiler room floor plating with new diamond plate; and, replaced wood bulkheads at the fore and aft ends of the engine room with steel watertight bulkheads.
1955	Smoke density indicator was installed.
April 1955	Due to rough water on bay, *Eureka* was reported to have suffered damage. Exact damage was unreported, but both pilothouses and superstructure needed repairs and re-sheathing needed to be removed to assess the area of the accident damage.
November-December 1955	Based on information in several memos from this time regarding heavy black smoke produced by the *Eureka*, evidence indicates that fuel system heaters in the fuel tank and under the fuel pumps were installed in the vessel in 1956; further research needed to confirm this theory.
February 25, 1957	Crank pin broke and the vessel was towed to the Oakland Mole, rather than a shipyard. No repairs were made, and the vessel permanently left service.
1957-1958	Southern Pacific donated the vessel to the San Francisco Maritime Museum. San Francisco Maritime Museum carefully transported the vessel to an abandoned ferry slip at the Richmond-San Rafael ferry terminal. Title of the vessel was transferred to the State of California in 1958, with the intent that the vessel would join the state-owned vessels that would be displayed at the new San Francisco Maritime State Historic Park at Hyde Street Pier.

March-June 1960	*Eureka* enterd drydock at Bethlehem Steel Company's Shipbuilding Division yard in San Francisco on March 25, 1960. Work was completed on June 15, 1960. Cost was $13,985. The vessel received extensive bottom maintenance including as follows: repaired and renewed several worm damaged bottom planks; replaced all damaged copper sheathing on bottom, stem, sternpost, and rudders with new copper bedded in tarred Irish felt; repaired worm damage in rudders; and, cleaned and coated steel paddle wheel rims.
1960-1963	*Eureka* was berthed at Oakland Dock and Warehouse Co. for repair and preparation for display as a museum vessel. Restoration took three years and was supervised by Karl Kortum and Harry Dring. Work was financed by the tideland oil revenues managed and distributed by the State Division of Beaches and Parks. Known work completed during this period included the following: San Francisco Maritime State Historic Park maintenance personnel installed an electric jacking motor for turning over the main engine (1960); San Francisco Maritime State Historic Park maintenance personnel modified restrooms and plumbing, and installed a sewage holding tank and associated plumbing to enable visitors and staff to use of the historic rest rooms (1962); Malott and Peterson Roofing Company of Berkeley renewed the roofing and floor coverings (1963); and, a collection of historic automobiles was placed on the main deck for interpretive purposes (1962-1963).
Ca. 1960-1968	Between 1960 and 1968, the window frames on most of the clerestory windows were repaired and/or replaced. Some original etched glass panes were replaced with plain glass.
October 2, 1963	*Eureka* was moved from Oakland to Hyde Street Pier in advance of the dedication and partial opening of the San Francisco Maritime State Historic Park.
1964	San Francisco Maritime State Historic Park maintenance personnel completed the following alterations and repairs: fire hose, axe racks, and lifering boxes were repaired or replaced; crew's locker room and washroom in Hold 5 were reactivated; pipe handrails were reinstalled; heavy rubber treads were installed on stairways and landings; the snack bar installed ca. 1941 was removed and new linoleum installed; and, sixteen blocks for boat falls were made and installed by master rigger Jack Dickerhoff.
1965	*Eureka* was drydocked at the Willamette Iron and Steel Company in Richmond, California. Following inspection of areas of the vessel's hull below the waterline, various portions of the hull were recoppered and new Irish felt installed. Additional work included, "rebuilding of damaged Gypsy heads," presumably existing hand winches on either end of the main deck.
1965	Repairs were made to hurricane deck, including replacement of rotten tongue and groove deck planking, rebuilding of handrails, and replacement of the four access ladders between the passenger and hurricane decks, to facilitate visitor access to the hurricane deck and pilot houses. Original access ladders were vertical and were located near the lifeboat stations.

January-June 1966	"Offshore" pilothouse was restored and outfitted for public access and interpretation. Extent of restoration work completed is not fully understood due to limited documentation of the project.
1973	*Eureka* was drydocked for cyclical maintenance and repair at Willamette Iron and Steel Company in Richmond, California including routine bottom cleaning, installation of bottom sheathing, and repairs to women's restroom, deck capstan, steam whistles, and funnel guy wires.
1978-1979	*Eureka* was drydocked for cyclical maintenance and repair at Todd Shipyard in Alameda, California. Maintenance included removal and replacement of fourteen sheets of plywood sheathing, bottom painting, exterior painting, and miscellaneous routine items. Repair was made to the foundation of the steel paddle box on the port side. The 7" x 14" x 45' sill timber beneath the paddle box was replaced, and the wasted lower edge of the steel paddle box bulkhead was repaired with a welded steel angle. While in drydock, additional work was authorized for repair of a 32' section of rubrail on the starboard side. Work included replacement of the wood components of the rubrail, and renewal of the steel chafing plate along the outboard side of the rail.
1982-1983	Partial replacement of seat and molding covers were made at *Eureka*, including birch veneer panels and metal flashing to match original.
1983	Lumber was procured for *Eureka* deck repair from Intermountain-Orient Inc.
1983-1987	Deck replacement completed by Bay Ship and Yacht Company.
1984-1985	*Eureka was* drydocked at Triple A Shipyard in San Francisco for maintenance and repair. Scope of work included cleaning all marine growth from the hull, removing and replacing sample of plywood sheathing for hull plank inspection, replacing beams and stringers in the way of the lifeboat and davits on the starboard quarter, and replacing 920 square feet of canvas covered tongue and groove decking. Additional scope of work covered renewal of deck beams and conjunctive repairs, and repairs to copper sheathing, caulking of hull, doubler on bottom, and repairs to sea chest openings.
1988	30,000 linear feet of Alaskan Yellow Cedar or Port Ordford Cedar was purchased for repairs to *Eureka*, from American River Lumber Company, Inc.
1988-1990	Roof replacement and repairs included reroofing the dome deck, installing roofing at men's and women's restrooms at the hurricane deck, and additional repair at roofing and decking using accurate replacement measurements and techniques. Work completed by ECO (US).
1989-1990	Repairs made to and coating of the smokestack and the walking beam. Work was completed by Pacific Drydock and Repair Company. Smokestack and associated assembly were removed by crane barge and transported to Pacific Drydock's Oakland yard. The fidley apron was refabricated during this work as it was discovered to be largely unsalvageable.

1993-1994	Drydock period for hull repair and coating. Scope of work included exterior hull repair with specified repairs and removals; refastening below the water line with specified removal and replacement of deteriorated hull-planking spikes; renewal to rubrail, deck beam, and spring beam; hull cleaning and painting, with surface preparation and coating of hull; repairs to the main deck; manufacture and install replacement bearing beams; open and inspect designated sea suction valves; refastening planking to the hull; support beam repair, with extensive deterioration found in the support beam; additional rubrail components, with extensive deterioration found in the rubrail; copper removal from hull and keel and installation; deck repairs to the fan ends (aprons) and support structure due to extensive deterioration; and upgrades to electrical services. Work was completed by San Francisco Drydock Inc.
1994-1995	Electrical and lighting repairs completed by Abbett Electric Corporation.
1999-2000	Drydock period for repair. Scope of work included hull cleaning; inspection and replacement of damaged planking; replacement of damaged copper sheathing; repair of main deck and rotten wood in hull; clean and overhaul sea suction valves including sea strainers, block and check valves, and painting the hull. Work completed under a modification of the original contract included fabrication of several dozen new windows due to excessive rot, installation of two hawse pipes, restoration of both paddlewheels (fabricate and install angle iron bracing) and paddlewheel houses, and additional replacement of sheathing fore and aft port and starboard main deck and passenger deck. Work was completed by San Francisco Drydock Inc.
1998-2001	Construction of the gangway and access ramp for the *Eureka* included timber pier construction, minor utility relocation, and design and construction of a steel access bridge to the vessel. Work was completed by Vortex Diving, Inc.
Ca. late 1990s-early 2000s	Park staff undertook modifications to Southern Pacific restaurant space.
1999	Electrical system rehabilitated.
2000	Kingposts rehabilitated to correct structural failure.
c. 2001	Asbestos abatement completed. Outer encasement (likely tin or canvas) portion of the steam chimney (plenum chamber) covering asbestos insulation was removed and not likely to have been saved.
2004	Undersides of overhanging passenger decks painted.
2005	Repair and replacement of curved windows at offshore pilot house.

2006	Engine room work completed including overhead and bulkheads painted and mechanical system rehabilitated.
2008	In-kind replacement of window sash on port main deck furthest forward.
2009	Completed work included replacement in-kind of deck edge stringer timber of the after overhang section of the hurricane deck; repairs to the area next to and forward of the port side lifeboat; repairs to passenger deck covering boards and removable rails; repairs to the fire sprinkler system; repairs to counterweight; painting and mooring maintenance; and emergency repair to stop valve leakage through hull opening.
2010	Completed work included lead paint remediation (encapsulation through painting) at the overhead and bulkhead surfaces of the passenger deck interior; application of Varnish/Paraffin/Solvent (VPS) blend to the wooden decks at the ends of the car decks, outside of the deck doors on both ends of the vessel; and emergency gangway repair, kiosk wiring, painting, and mooring maintenance.
2011	Completed work included repair work to the covering board and windows; repairs to lighting and heating at the passenger deck; recoating at tops of wheelhouses; elastomeric paint to davit deck; repair to benches at passenger viewdeck and offshore deck; repair to passenger deck outboard rails; installation of safety wire rail; repair to door of wheelhouse; repair to rolling door; rehabilitation of sliding doors; widow repair; repair to ladder to foreward pilothouse; preparation and painting bulwarks and furniture at passenger viewdeck; general painting; and mooring and gangway maintenance.
2012	Completed work included ladder repair and ladder replacement; handrail repair; bench repair at passenger viewdeck and offshore deck; repair to car deck stanchions; electrical repairs; installation of high volume pump; nailed threshold plates at pilot houses; repair to offshore pilot house; plugged scupper; linoleum repaired; repair to pump; repair to generator housing; repair to seawater suction valve; repair at outer mooring; stabilization of rub rails; installation of new handrails on offshore dome deck; repair to sole in Junior's hold (#5); installation of canvas skirts under benches; and painting dome deck and trim.

2013	Completed work included repair to leaking suction valve penetrating the hull in the area of the engine room; repairs to shore up after car deck in the area of the stair box; repairs to tongue and groove sole in Junior's Hold (#5) which suffered from local areas of rot; routine cyclic maintenance including preparing and coating the weather decks of the vessel with elastomeric paint in kind with existing; preparing and painting wooden exterior covering boards and trim features; preparing and painting as necessary deck furniture and stairway boxes and stairs in red oxide to match original; preparing and painting as necessary vertical outdoor bulkheads in to match original; preparing and coating canvas decks with suitable oil-based marine acrylic paint to match existing; treating, priming and painting mooring chains to prevent corrosion and staining; cleaning and borate treating wooden car deck; borite treating wooden framing in lower holds and bilge areas; gangway repair; smokestack cap removal; painting at passenger view deck; repairing and painting port side; refastening cardeck; repairing windows; bench repairs; repairing areas of covering board and railing; repairing dome deck; installing stanchions; painting bulkheads at exterior of passenger deck; painting canvas deck; painting passenger deck; and painting exterior of wheelhouse.
2014	Completed work included demolition of non-historic fabric/furniture at off-shore wheelhouse; stabilization and repair of rotted framing; repair/replacement in kind of rotted windows and frames; removal of carpeting and sub-flooring; paint and coating analysis; removal of unattached components to secure location; patterning and demolishing covering board; installing deck plate hardware at engine room; installing gangway apron; and replacing electrical box.
2015	Completed work included installation of counterweight system (attached by chain through a hawse pipe); repair to a leak at the hurricane deck; painting inboard surfaces; adjusting moorings; cleaning including fresh water and soft brush on exterior surfaces; sweeping and vacuuming on interior; replacement of offshore cradle components; pest removal including racoon barriers; fastinging plywood panels to historic fabric; and resetting wedges for support posts at the aft hold.
2016	Completed work included replacement of fluorescent light with LED bulbs; adjusting moorings; refastening loose wear deck planking; replacing bilge pump; replacing bow fender tire; replacing strongback and decking at port aft mooring cleat; stabilizing port bow; applying elastomeric paint to dome and hurricane deck; and replacing chafing gear.

2017	Completed work included replacement of smokestack cap (lost to wind in 2013); original steel cap reproduced in aluminum and painted black; new cap secured to the ship via stainless wire (sub for original steel chain) to turnbuckles; adding a stern line; repairing hurricane deck beam; repairing passenger deck bench and handrails; repairing hurricane deck ladders and a leak; installing bilge pumps; repairing onshore pilothouse deck beam and ladder; replacing chafe gear; painting flag staff, metal ring frame, and stanchions; repairing flagpole; and striking flagpole.
2018	Completed work included replacement of stud-link chains that hold vessel to the mooring pilings at Hyde Street Pier; work to provide safe public access to the engine room by installing five metal safety stanchions and attached rope/netting for the control platform; repairing handrails at passenger deck; repairing starboard boat davit; replacing fender at port bow; preparing and painting lifeboat; refinishing outside passenger decks; repairing and painting aft pilot house; and adjusting moorings.
2019	Completed work included restoration of paint and wood at the shoreside of the car and passenger decks, including the stairs; repairing cover board Dutchman; repairing benches including milling wood and installation; painting dome deck and pilot house; painting davit area; painting passenger deck; painting metal pipes; painting rails, coverboards, and gates; and painting stairway and stair kicks.
2020	Completed work included repair to railing at passenger deck; repairing weather offshore davit area; replacing Dutchman for cover board; replacing mooring chain; and replacing pilothouse window.
2021	Repair to rotten wood in davit areas, windows, and cover board on the dome and hurricane deck. Painting of offshore side of the vessel. Lead abatement at roof of outdoor areas on the bow and stern at the car deck and passenger deck. Areas prepped and two coats of SAFR approved primer applied; two topcoats of SAFR approved oil based marine enamel applied on all surfaces. Repair to pilothouse including removal of corner curved windows in both pilot houses, fabricate of new frames; bedding the original glass into new frames; and reinstallation of windows.

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Section Five

Physical Description

SPECIFICATIONS

Length	299’ 6” at deck
Beam	78’ at deck
Depth	15’ 7”
Gross Tonnage	2,420
Net Tonnage	1,500[90]

The following physical description presents the present general arrangement of the *Eureka*’s material features, with information about prior alterations and restoration of features where applicable.

GENERAL ARRANGEMENT

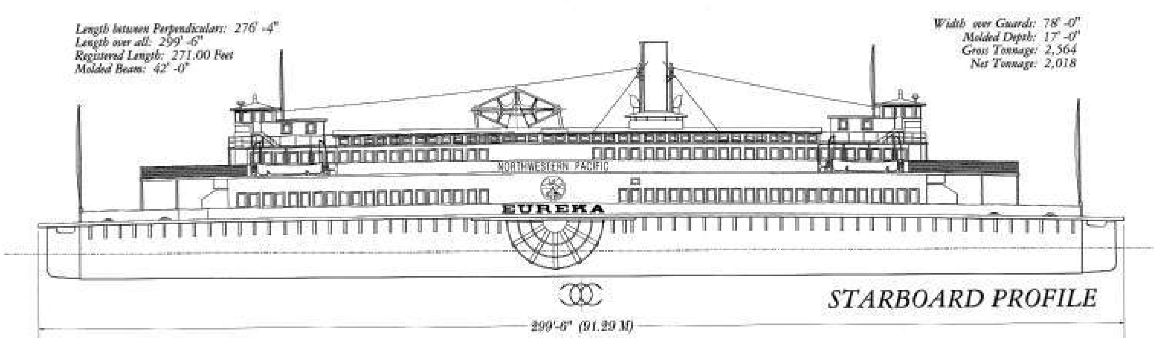
The *Eureka* is a double-ended ferry with a generally laterally symmetrical arrangement. The vessel is currently docked with its bow end in, and the bow, stern, and starboard side of the vessel are visible to visitors from the Hyde Street Pier while the port side is visible primarily from vessels and vantage points further east. Above the hull, the “house” projects out to create a sponson deck and encloses most of the main deck and passenger deck. The hurricane deck and dome deck form the roof of the house.

There are two pilothouses, one at each end of the hurricane deck, and the smokestack and top of the walking beam project above the center of the dome deck. The exterior of the house is clad in horizontal tongue-and-groove and painted white, and there is a large painted crest midship at port and starboard that reads “Northwestern Pacific” and depicts a redwood tree, bay waters, and stylized landforms.

HULL

The *Eureka* is built almost entirely of Douglas fir and is iron fastened. The hull is carvel planked with 4” thick planking fastened by galvanized ship spikes to double-sawn frames. The hull is ceiled from the sheer to just below the turn-of-bilge. The ceiling varies in thickness from 3 3/4” at the sides to 5 1/2” at the turn-of-bilge. Frames vary in molded dimension from 9” at the sheer to approximately 14” below

[90] Porter, “Addendum, Ferry *Eureka* HAER,” 2.



Starboard profile of the Eureka (Richard K. Anderson Jr., 1996)

Typical hull interior materials, components, and arrangement (ARG, October 2021)

Detail of starboard sponson deck, rub rail, and paddlewheel (ARG, October 2021)

the turn-of-bilge. Frame spacing is 24” on center. The floor timbers are 15-3/4” molded. A single 20” x 20” keelson timber runs the length of the hull. Four 16” x 16” sister keelsons along the bottom between centerline and the turn-of-bilge provide additional longitudinal stiffening. A latticework of steel “hogging straps,” designed to reduce flexing and bending of the hull, are positioned between the framing and hull planking along the entire length of the hull. These are 1/2” x 5” steel straps that are set diagonally and riveted together to form a strong steel mesh. The bottom of the hull is sheathed with copper.

Sponson decks are supported on the hull’s interior and exterior by hanging knees, and at the interior by alternating hanging knees and support braces. The vessel’s two side paddle wheels are located at mid ship. Each wheel is 27’ in diameter with twenty-four 12’ 9” by 22’ buckets. The portions of the paddle wheels that are normally submerged are missing due to corrosion. The wheels are enclosed above the hull by riveted steel paddle boxes. The structure supporting the paddle wheels and boxes consists of a large truss built into the vessel’s structure. The truss comprises the forward and aft deck beams surrounding the paddle box, which span the width of the vessel; four king posts; bearing beams; and a series of large diameter truss rods.

The structure provides primary support to the weight of the drive shaft and of the paddle assemblies that extend beyond the vessel’s hull.

Below the main deck, six watertight bulkheads (two steel and four wood) divide the hull into seven compartments, including the forepeak, Hold #2, Hold #3, the engine room, Hold #5, Hold #6, and the afterpeak. Hold #5 includes a ‘tween deck, while other holds include partial ‘tween decks and platforms.

The forepeak and afterpeak are located at the fore and aft ends of the hull respectively. The forepeak is 17’ 5” in length and the afterpeak is 17’ 3” in length. The peaks have no intended usage and are presently empty, with exception of the stern mooring chain in the afterpeak. There is a partial platform in each peak, and the peaks are accessed through small hatches in the main deck, and though the bulkheads.

Hold #2 is 18’ 4” in length and includes a partial ‘tween deck used for storage of the emergency bow anchor. Access is through a hatch beneath the forward passenger deck stairwell.

Hold #3 is 48’ 0” in length, and includes a steel bulkhead

at its aft that encloses the engine room. Hold #3 includes a partial 'tween deck which supports the steam steering engine for the bow rudder at port, and is also used for storage. A steel potable water tank is located in the bilge.

Hold #4 is the engine room and is located in the midsection of the vessel. At 95' 8" in length, it is the largest hull compartment, and is enclosed fore and aft by steel bulkheads. The engine room is accessed by ladder from the control room, which sits just below the level of the main deck within the large, riveted steel engine room casing (enclosure). The engine room houses the walking-beam engine and the four fire-tube boilers, along with most of the vessel's steam auxiliary equipment, two operational bilge pumps, and a sea-suction valve. (Machinery within the engine room, and all other machinery systems on the vessel, are described in later sections of Chapter Five.) A catwalk has been installed to provide access to the upper portions of the compartment on the outboard sides. Ceiling throughout the compartment is stiffened by the addition of cedar shims. Some hanging knees in this compartment are braced with steel plates which were added during a 1993-1994 drydocking. Decking is installed above the lower frames and floor timbers.

Hold #5, directly aft of the engine room, is 48' in length, with a steel bulkhead at its fore that encloses the engine room. This compartment was formerly a crew's locker room. A full 'tween deck serves as storage, and deck beams provide the support structure for the vessel's aft steering engine. The compartment includes two large steel tanks; one on the port side for fuel oil, and one at starboard for boiler feedwater. A wastewater holding tank and waste processor for the operational restrooms on the passenger deck has been installed on the starboard side. The area below the 'tween deck is empty, except for the tanks, which extend below the 'tween deck level.

Hold #6 is 24' 8" in length and includes a partial 'tween deck where the chain for the emergency stern anchor is located. Access is through a hatch in the main deck between the aft wall of the house and the aft capstan.

MAIN DECK

The main deck was designed to carry automobiles and is largely undivided to enable easy on- and off-loading and to maximize space. The main deck is longitudinally planked with 3-3/4" x 3-3/4" decking laid on 6" x 8" deck beams. The entire deck is covered with tongue-and-groove cedar sheathing.

The sponson deck is supported by the main deck beams and, at the fore and aft ends, by a series of radiating beams or "fan timbers." The outboard portions of the deck beams are supported by hanging knees and 6" x 6" diagonal braces in alternating sequence. A "rub-rail" intended to serve as a fender is comprised of several heavy timbers and extends around the entire perimeter of the main deck. Two massive "spring beam" timbers measuring 23" x 30" x 45', are located along the outboard edge of each paddle box.

The fore and aft portions of the main deck are located outside of the house. Both ends of the vessel are similarly arranged, with the terminus open to facilitate on- and off-loading of people and autos via a gangway, and the sides enclosed by wood half-walls with metal pipe railings and scuppers; a low railing currently encloses the terminus of the stern end of the main deck as the vessel is permanently moored bow in. Cleats are arrayed around the perimeter of the open deck area. A centrally located bifurcated stair with turned newel posts and concrete bumpers rises to the passenger deck, which is supported at the main deck by riveted metal girders and perimeter posts. The area below the stair is enclosed and used as storage, and an anchor capstan is located behind each stair, along with a rack to hold the wood turning posts.

Access to the interior of the house at the main deck is via large, partially glazed, rolling wood-paneled doors. The interior is largely undivided and supported by steel posts and riveted metal girders. Forty-four fixed undivided wood windows line the port and starboard sides of the main deck house. The riveted steel engine casing is located at the centerline midship. Access to the control room is provided

Exterior bow end of main (car) deck showing stair to passenger deck (ARG, October 2021)

Interior of main deck, stern end, showing passenger seating (ARG, October 2021)

via a split metal door at the aft wall of the engine casing, and there are several additional metal doors and viewing ports at its port and starboard walls. Likewise, paddle boxes are of riveted metal are located port and starboard midship and include several metal doors and viewing ports.

Simple wood benches are located along the interior of the port and starboard walls of the main deck, and several additional shaped wood and metal frame benches are arranged in freestanding locations towards the aft of the deck. Approximately two dozen cars and trucks dating from the 1910s, 1920s, and 1930s are currently located on the main deck for display purposes; these vehicles are enclosed by movable wood fencing and/or low enclosures of plastic-coated metal screen. Additional movable items within the main deck house include interpretive panels, several models, and wood storage chests.

PASSENGER DECK

The passenger deck served as the main passenger space on the ferry. It is 242′ long, with a width of 36′ at the fore and aft ends and a maximum width of 76′ at midship. Most of the passenger deck is enclosed by the house.

The passenger deck is constructed of 1-1/8″ x 3-1/4″ tongue and groove decking on 2-5/8″ x 5-1/2″ and 3-5/8″ x 5-1/2″ deck beams. The deck is supported by the engine room casing and the paddle box bulkheads, and by eight riveted steel girders, four forward and four aft of the paddle boxes. There are two major longitudinal deck stringers, one port and one starboard, made up of four 1-3/4″ x 11-1/2″ timbers laminated together and supported by steel pillars. Additional smaller stringers are located at the deck edge, at centerline, and at the fore and aft ends of the passenger deck. The line of these longitudinal beams sags slightly around the restrooms and paddle boxes, indicating structural problems elsewhere in the vessel.

The passenger deck is accessed from the main deck via two bifurcated stairs located fore and aft of the house. Each stair is surrounded by metal tube railings and continuous wood benches. Areas of the passenger deck outside of the house are enclosed by wood railings with plastic-coated metal screen and decked with painted and tacked canvas. Steel posts support the hurricane deck, which is accessed via two metal ladders both fore and aft. Beneath the hurricane deck there are fixed metal and wood benches and a small wood storage closet. Lifeboat chocks and cantilever davits are located at each “corner” of the passenger deck; lifeboats were removed during drydocking in 1984. The aft

Exterior stern end of passenger deck (ARG, October 2021)

Interior port side of passenger deck (ARG, October 2021)

end of the passenger deck underwent a major rebuild in 1985; pillars, stringers, deck beams, decking, and canvas deck covering were renewed.

The interior of the house at the passenger deck is accessed both fore and aft via two paired half-glazed sliding wood doors. The fore and aft walls of the house include fourteen fixed undivided wood windows, while port and starboard walls include thirty-two fixed undivided wood windows, some of which are shortened to include open metal ventilation lattice. The central height of the interior is raised to include a clerestory level with a continuous band of windows, some of which are operable and include etched glass.

The interior of the house at the passenger deck includes a tongue and groove cedar ceiling with exposed rafters, supported by wood posts with stepped corbelled caps. Additional ornament includes carved corner brackets with a fan motif, decorative wood moldings, and fluted bell-shaped milk-glass and brass electrical light fixtures.

Midship at port and starboard are paneled enclosures which include restrooms and storage areas. These enclosures are accessed via several half-glazed wood panel doors and are lit by clerestory windows. The riveted steel engine casing is

Interior fore portion of passenger deck showing former location of restaurant dining area (left) and galley (right) (ARG, October 2021)

located at the centerline slightly aft of midship; an enclosure aft of the engine casing includes a half-glazed wood panel door and windows and historically served as a news stand.

The riveted steel smokestack casing is located at the centerline slightly fore of midship. A full-height enclosure wraps around the fore and port sides of the casing and is constructed of wood beadboard and fixed windows. This enclosure historically operated as a galley kitchen

for the vessel's restaurant; all historic fixtures have been removed and the room is used for office and storage. Fore and starboard of the casing and enclosure, wood panel partitions enclose an area formerly used as restaurant seating: fixed benches line the walls of the enclosure and interpretive signage is affixed to the partitions.

The remainder of the interior passenger deck is occupied by fixed single- and double-sided benches. Benches have wood and metal frames with arm rests supported by turned wood posts. Seats are bent and tacked wood, and the area below includes storage racks covered by canvas flaps. The floor around passenger seating is covered with painted linoleum.

Hurricane deck (foreground) and dome deck showing fiddley and smokestack (ARG, October 2021)

HURRICANE DECK

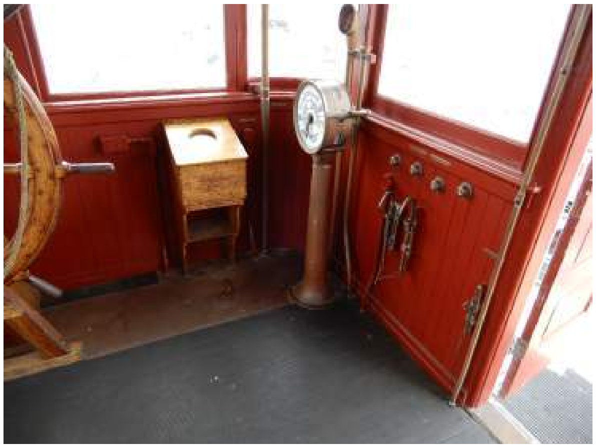
The hurricane deck is accessed from the passenger deck via four metal ladders, two fore and two aft, which replaced ladders originally located further port and starboard after 1958 to provide easier access for park visitors. The hurricane deck is an open deck that along with the dome deck forms the roof of the house. The hurricane deck is constructed of tongue and groove decking on 1-3/4" x 3-1/4" deck beams, supported by a series of longitudinal wood stringers on wood pillars. The hurricane deck was originally canvas covered but has been recovered with layers of fiberglass and roofing tar. The hurricane deck is interrupted by the passenger deck clerestory, both at the center portion of the vessel and at midship port and starboard above the restrooms and storage areas. The perimeter of the hurricane deck is enclosed by an iron railing.

Port side of bow end pilothouse (ARG, October 2021)

PILOTHOUSES

The vessel's two pilothouses are situated at the fore and aft ends of the hurricane deck. Both pilot houses have a rectangular footprint and horizontal tongue and groove cladding, and are generally similarly arranged, with a raised piloting room at fore and two at-grade crew rooms aft. At each pilothouse, the raised piloting room is accessed from both port and starboard by a short metal stair and landing.

Each piloting room includes half-glazed wood doors port and starboard, and is enclosed by continuous undivided wood windows, some of which are operable in a drop-down pocket arrangement. Brass and wood steering and operational apparatuses are arranged along the fore of the room (including a non-original wood wheel at the bow


Interior of bow end pilothouse (ARG, October 2021)


Dome deck midship, detail of riveted steel A-frame and cast-iron walking beam (ARG, October 2021)

pilothouse) and fixed furniture including a padded bench and cabinets are located at the aft. Interior finishes include beadboard walls, tongue and groove cedar ceiling with exposed rafters, and a fluted bell-shaped milk-glass and brass electrical light fixture.

Crew rooms are accessed via wood paneled doors and include several undivided wood windows, some of which are operable in a drop-down pocket arrangement. Interior cladding is horizontal tongue and groove. Appointments include simple bunk beds, bench seating, small closets, and corner-mounted porcelain sinks. A very small arched door in the stern pilothouse enables pass-through between the pilot room and crew quarters.

DOME DECK

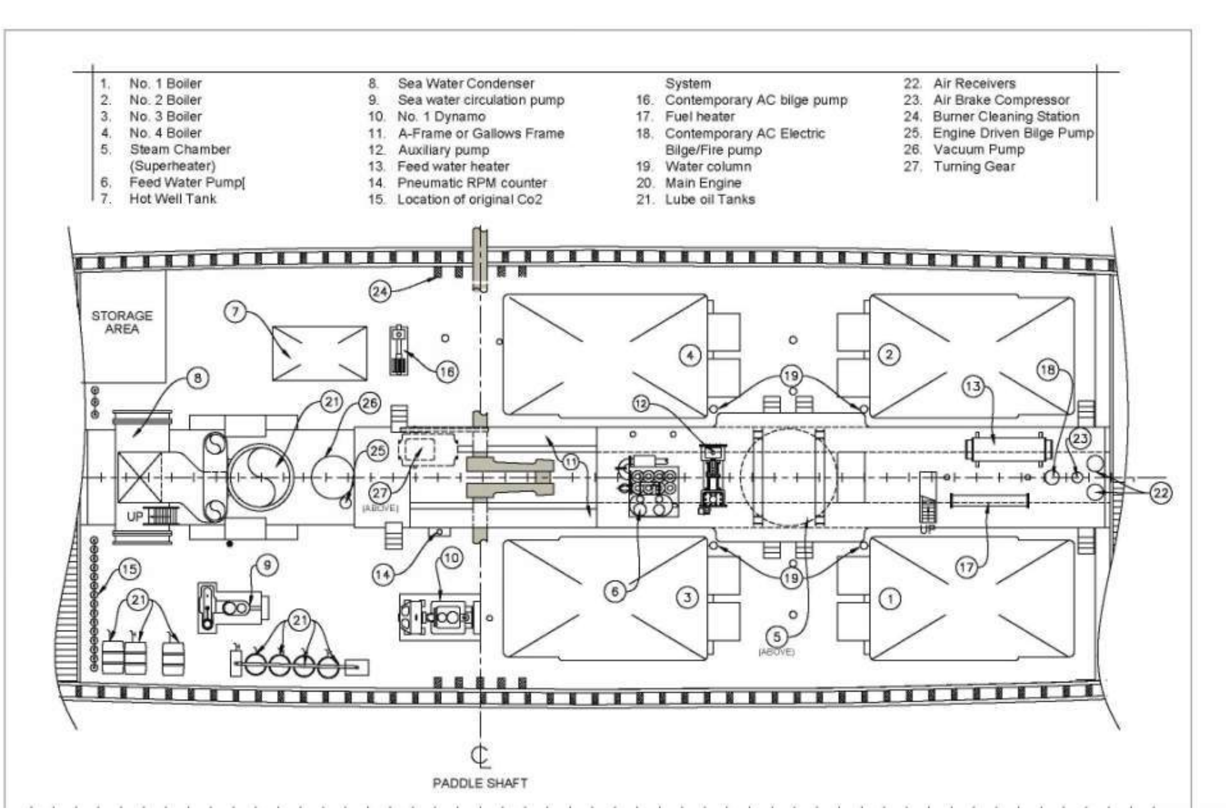
The dome deck is an open deck that along with the hurricane deck forms the roof of the house. Dimensions of the dome deck are 42' x 134' and it rises approximately 3' above the level of the hurricane deck. The dome deck is constructed of tongue and groove decking on 1-3/4" x 3-1/4" deck beams, supported by a series of longitudinal wood stringers on wood pillars. The dome deck was originally canvas covered but has been recovered with layers of fiberglass and roofing tar.

Fore of midship, the square metal fidley rises above the dome deck and includes four ventilators and the steel smokestack, which is secured by four tiedowns. Metal ladders and tripartite whistles are affixed to the fore and aft of the smokestack. Aft of midship, components of the walking beam engine project above the dome deck, including the riveted steel A-frame and the cast-iron walking beam.

MACHINERY SPACE

The following sections of Chapter Five were authored by Anthony Guild.

The *Eureka*'s machinery space is the largest compartment in the hull of the vessel. The space houses four horizontal fire tube boilers on the permanent forward end of the vessel and the balance of the propulsion machinery are located throughout the machinery space. Walking beam engine and steam system auxiliaries with the exception of the vessel's steering engines are located as outlined in the below figure which can be used as a reference to the machinery equipment on the vessel.



General arrangement of engine room equipment (Tri-Coastal/De Pavlof Co. 1990; modified by Anthony Guild, 2022)

Engine Room

The engine room is located in the midsection of the vessel, measuring 95′ 8″ in length from the steel bulkhead at frame s28 to the steel bulkhead at frame o18. This compartment houses the walking-beam engine and the four fire tube Freeman Dryback boilers. Most of the steam auxiliary equipment is also located here, along with the vessel's two operational bilge pumps and single sea-suction valve. In 2016, the sea valve was blanked off outside the hull due to a leak that could not be repaired in the water.[91]

Access to the engine room is through the control room, a small platform just below the main deck level at the aft end of the engine room casing and via a vertical ladder and hatchway from the car deck that lands between boilers one and two. This access point was arguably the main access to the engine room for the unlicensed engine room crew.

A-Frame

The "A" frame, or "gallows frame" on the *Eureka* acts as the main foundation and support structure for the walking beam steam engine and much of its stationary and rotating machinery. The A-frame was originally a wooden structure consisting of hardwood, steel through-bolts, and wood stabilizing knees: the original A-frame was removed and replaced by a riveted steel A-frame when the vessel was

[91] Anthony Guild, personal communication, March 29, 2022.

overhauled between 1920 and 1922.[92] The steel structure is mounted to longitudinal wood timbers that in turn are fastened to the vessel's floors.

Walking Beam Steam Engine

The walking beam steam engine is an all-steel structure that originates in the engine room and projects up through openings in the dome deck. The engine was built with jet condensing but was fitted with a surface condenser at an unknown date, believed likely to have been 1922 when the A-frame was overhauled from wood to steel.[93]

The walking beam can be observed above the dome roof. The beam is strapped with a forged steel rim and is keyed onto the spokes. The working portions of the walking beam are keyed in place with "U" straps and taper keys. The cast-iron beam sits atop the A-frame. Below the dome deck, the stack and A-frame are enclosed by the engine room casing.

Steam Chimney

Located above the four boilers on the main deck, the vessel's steam chimney, which is also referred to as superheater, is a steam jacket that surrounds a segment of, and is fabricated as an integral portion of the exhaust stack. Essentially, the steam chimney surrounds the exhaust smokestack. Steam is directed into the steam chimney from each boiler's main steam line and is connected at each boiler's main steam stop valve. The stop valves are located on the car deck through access doors that lead into the machinery space. The steam chimney acts as a combined steam drum and steam superheater for the vessel. Steam is superheated as it passes through the steam stop when it comes into contact with the steam chimney's inner surface.[94] This process was designed to capture some of

Steam Stops at Steam Chimney (Anthony Guild, 2022)

the boiler's hot exhaust gases otherwise wasted through the ship's exhaust stack and helps flash off any moisture carryover in the steam and superheats the steam to ensures complete heat saturation.

Boilers

Steam for *Eureka*'s walking beam engine and auxiliary equipment comes from four horizontal fire tube Freeman style dryback riveted steel boilers. The boilers were built by the Seattle Construction & Drydock Co. in Seattle Washington in 1913 and the boiler's tube sheets (plates) were fabricated by North Bros, Co. of Coatesville, PA and were fitted for 3" rolled tubes. They were designed with a tensile strength of 60,000 pounds. The boilers consist of a large horizontal cylindrical drum with a front furnace and a rear combustion chamber with a multi-layered brick back. The ship's forward two boilers are forward facing, and the two aft boilers are aft facing. This configuration enabled the ship's crew to observe the front of all four boilers from a single vantage point in-between the boilers. The water columns, fuel burners, and steam atomization lines are all located at the front of the boilers.

The oil-fired burner for the boiler is a rudimentary burner system that consisted of a single fuel line that fed a simple burner nozzle. Steam was injected into the fuel line before the nozzle to help atomize as it entered the combustion chamber. The result increased burner efficiency of the boiler. Burner maintenance was likely performed on the

[92] Harlan and Fisher, *Of Walking Beams and Paddle Wheels*, 68, 73.
[93] Anthony Guild, personal communication with Channing Walker and Erik Olson, March 29, 2022.
[94] Steam is described as superheated when it has been heated above saturation temperature. In this case saturated steam is produced when the steam in the steam chimney is exposed to the hot surfaces in the chimney's inner surface causing the steam temperature to increase above the evaporating temperature.


Front of Boiler No. 2 (Anthony Guild, 2022)

port side of the vessel where there is a pipe clamp mounted to the timbers under the main drive shaft bearing support. The clamp is cast with a date from 1914. Each boiler is fitted with a dual Lunkenkeimer steam safety valve with chain easing gear, which is no longer connected as originally installed.

The water level of each boiler was observable in the water column or water level indicator. This equipment is an externally mounted water chamber with a gauge glass with three water cocks attached and is located at the forward end of each boiler. The gauge glass and three valves were used by the crew to maintain water at the correct level. The front of the boilers also houses the fuel oil burners. The burners consisted of a rudimentary fuel supply line with a steam line also attached to assist in the injection and


Water Column (Anthony Guild, 2022)

atomization of the fuel into the boiler combustion chamber.

Condenser

The vessel's surface condenser is located just aft of the engine and dates from 1933 when it was installed. This information is based on stamped text located the starboard side tube sheet of the current condenser. The stamp reads: *"Installed Sept 1933, No of Tubes 1678, Length of tubes 10' 6 7/8"."* It is not known if the condenser was a replacement in kind or renewed with a different make or model from the ship's original.

The *Eureka*'s condenser reflects technological improvement to a completely closed looped steam system. The condenser improved the ability of the machinery plant to recycle spent


Steam Condenser (Anthony Guild, 2022)


Saltwater Circulation Pump (Anthony Guild, 2022)

steam that had expended its heat and had returned partially or completely back into water (condensate). The steam condenser helped finalize this part of the steam cycle and then the condensate was transferred to the hot well, where it eventually reentered the boilers as feed water. A small percentage of the tubes have been plugged, likely due to tube failure. This was a customary type of temporary repair to prevent saltwater contamination of the condensate system when a tube failed in service.

AUXILIARY MACHINERY

The auxiliary steam machinery, are typical of steam equipment of the early 1900s. As noted in the 1990 Draft Ferry Steamer *Eureka* Historic Structure Report, "Most of these items were manufactured for general marine or industrial use, and near-identical examples likely exist elsewhere. All of the steam machinery dates from the historic period, though the date of the origin of individual items is uncertain."[95] Where information from a manufacture's identification label or a casting stamp was discovered it is described as found.

Saltwater Circulation Pump

The saltwater circulation pump is a cast-iron split case centrifugal pump powered by a vertical steam engine

[95] Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," 47.

similar to the steam engines that powered the ship's two DC dynamos. The pump provided saltwater to the surface condenser and was a critical part of the vessel machinery: the make and manufacturer of the pump is not known. The pump can take seawater suction from two places: the turn of the bilge on the starboard side of the ship just forward of the pump, and just aft of the pump adjacent to the emergency engine room bilge suction. The emergency bilge suction was designed to allow the use of the saltwater circulation pump as an emergency dewatering pump in the event of flooding in the engine room. The pump's cast-iron housing is cracked by what appears to be rust expansion from inside of the housing.

Attached Primary Bilge Pump

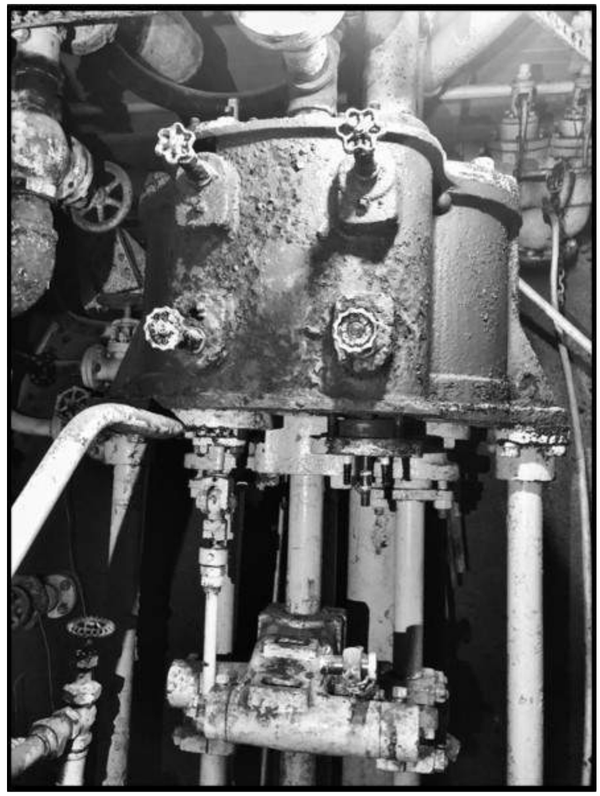
The vessel's primary engine driven vertical driven plunger style bilge pump has been removed from the vessel (date unknown). The pump was located on the starboard side of the engine just aft of the A-frame and adjacent to the air pump. The pump is reported to remain in NPS custody, located off site at one of the NPS warehouses.[96]

Fuel Service Pump & Heat Exchanger

The steam-driven fuel pumps for the boiler's burners are no longer on the vessel. They were located adjacent to the fuel heat exchanger on the flat in between the number one and two boilers. The pumps were reported to have been removed before the vessel was transferred to museum use. No information on the make and model of these pumps is available. The pumps transferred fuel from the fuel tank through the fuel heat exchanger and supplied fuel to the boiler's burners.

General Service Pump

The general service pump is a Fairbanks Morse horizontal pump with double acting plungers.[97] This pump is also often referred to as the "donkey pump" which is the vessel's historic bilge, fire, and sanitary discharge pump. The pump



Boiler Feedwater Pump (Anthony Guild, 2022)

is located on the forward end of the flat between boilers three and four. The pump could also take suction from the feed water tank, bilge manifold, hot well tank, and directly from sea through a manifold adjacent to the pump. The general service pump served as a backup feedwater pump for the ship's boilers and much of that piping is no longer present due to reportedly being stolen at some point in the past. The general service pump does not have any labels or markings as to its original manufacture or installation date.

Fire and Sprinkler Pump

The vessel's primary fire and sprinkler pump is a horizontal plunger style pump located inside the machinery space on the car deck. The fire and sprinkler pump appears to be original equipment, although as with other pumps on the

[96] Anthony Guild, personal communication with National Park Service Ranger Christopher Edwards, March 23, 2022.
[97] The pump tag includes unspecified unit dimensions of 8 x 6 x 12, believed to represent the diameter of the steam cylinder, diameter of the water plunger and length of stroke.

Contemporary Bilge Pump (Anthony Guild, 2022)

Contemporary PVC Bilge Manifold (Anthony Guild, 2022)

vessel, it is unlabeled and has no manufacture markings.

Boiler Feedwater Pump

The boiler feedwater pump is a vertical steam-powered pump located in the engine room on the flat between the number three and four boilers. Feedwater is piped from the hot well tank to the feedwater pump through a float driven throttle valve. The float is mounted just aft of the feedwater pump.

Contemporary Fire Pump

A contemporary fire pump was installed to improve the firefighting capability of the ship while in museum service; exact installation date is not known. The pump is in the forward portion of the engine room between boiler number one and two and is hard piped to the vessel's fire stations. The pump is powered by a 230 VAC 3-phase electric motor that has its own electrical service from a contemporary power panel in the transformer room. The pump is reported not to be currently in service.

Contemporary Bilge Pump

Modifications to the vessel's bilge system were designed and presumably installed in the 1980s. The design converted the ship's hot well tank into a 1,500-gallon holding tank and installed a manifold and a self-priming bilge pump. The pump was installed just aft of the number three boiler and the bilge manifold was installed

inboard of the converted hot well tank. The system included a submersible pump in each of the vessel's bilges to automatically start and stop using an electric float switch. The main pump was a 220 VAC three phase, five horsepower ITT Marlow self-priming pump model 3DTH.

Steam Powered Air Compressor

The ship is fitted with a Westinghouse Air Brake Company (W.A.B. Co) steam powered air compressor. The compressor was used to provide compressed air for the vessel via the ship's two air receivers located at the forward end of the engine room.

Turning Gear

While the *Eureka* is docked, the paddle wheels and walking beam engine can be rotated with a chain-driven turning gear. The gear is labeled "Jones Gear Drive Serial Number 377447/1," and has a casting that reads "Jones 540205," indicating that the gear box has a ratio of 291 with an input RPM of 230. The unit is powered by a 230 VAC 3 PH 5-H.P. electric motor.

Pneumatic RPM Counter

A chain-driven pneumatic RPM indicator is mounted to the starboard side of the main engine A-frame and appears to be intact.

Steering Engines

As a double ended steam ferry, the *Eureka* is outfitted with two helm stations and two independent rudders. Each rudder is controlled through the helm steering station that is connected to its respective steam steering engine. Each steering steam engine is a large horizontal nondifferential steam-operated cylinder with a single interconnected piston that extends from each end of the steering engine cylinder. Each end of the piston is connected to a drive chain that runs to the extreme outer end of the rudder and back. As the steering wheel is turned, chain and rod linkage that interconnects the wheel with the steering steam engine control valve calls for steam to be introduced into one side of the piston, causing the piston to move horizontally and the rudder to react. The horizontal movement pulls the attached chain which in turn pulls the

Rudder Steering Chain (Anthony Guild, 2021)

rudder in the direction ordered. As the rudder moves, the chain from the free end of the rudder is also pulled. Since that chain is attached to the other end of the nondifferential piston, the rudder is easily controlled by the pulling of opposite ends of the piston as it shifts from one extreme position to the other.

The steam engines were designed and patented by John Bonner of Tiburon, California, where the vessel was constructed. As described in Canadian Patent No. 50,273, the *Eureka*'s steering engine is a horizontal steering apparatus with the original design having the drive chain interconnected to the steering wheel.[98]

ELECTRICAL SYSTEM

The electrical system on the *Eureka* is a combination of equipment, fixtures, and wiring from the vessel's original shipboard system, and components that were added to serve the present AC shore-power system. The electrical system was originally powered by a DC Dynamo; an additional Dynamo was added along with a new DC

[98] Ottawa Government Printing Bureau, *The Canadian Patent Office Record* (Ottawa Government Printing Bureau, Ottawa, Ontario, Canada, Vol XXIII, 1895) 25, 944.

switchboard in 1953.[99] As noted in the DC switchboard label, the equipment was installed by the Moore Drydock company in Oakland, California. The No. 2. Dynamo is located in the electrical room on the main deck aft of the superheater. An electrical survey completed in 1992 accurately describes the ship's electrical configuration:

> "The original electrical system for which was designed for 110 volts DC has been mostly rendered inactive. A new AC system was installed which provides electricity for some lighting, bilge pumping, firefighting and other activities required for service as a museum ship. Electrical power is no longer generated on board but supplied from shore via flexible cable. A part of the original ship cabling was utilized for lighting, but motor drives were changed from DC to AC three phase motors, which required new cables. in addition, an isolation transformer system was installed to isolate the electrical system on board from the shore system to eliminate possible electrolysis damage."[100]

Although some additional electrical work has been completed on the vessel, no existing drawings have been uncovered that accurately reflect the AC system as it is configured today, or the vessel's original DC electrical system.

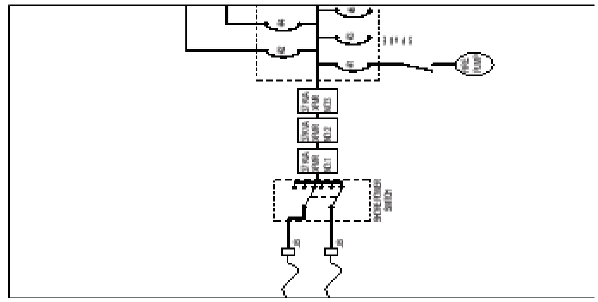
Dynamo No. 1

Dynamo No 1 is located in the engine room just aft of Boiler No. 3. Dynamo No 1 is a Sturtevant engine with a Westinghouse 120-volt, 160 Amp 20 kW DC type marine generator powered by a vertical single short stroke high-speed reciprocation steam engine. The label of the steam prime mover is missing but the tag on the Westinghouse DC generator indicates that it was installed on the vessel sometime around 1916.

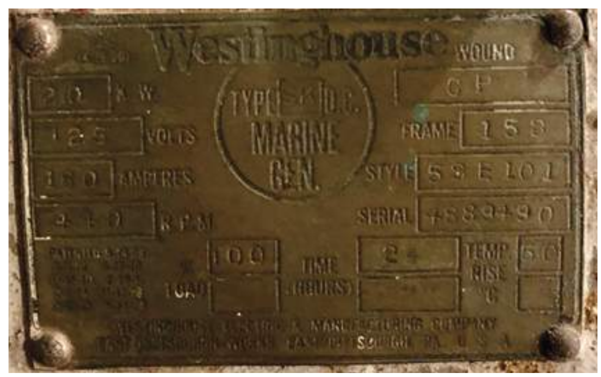
Dynamo No. 2

[99] Anthony Guild, personal communication with Channing Walker and Erik Olson, March 23, 2022.

[100] Eckart Schroder, Designers and Planners, "Draft Electrical Survey of the Ferryboat *Eureka*," Arlington, Virginia, Report No. 100-92-006, 1992.



Single line diagram, AC electrical system (Anthony Guild 2022)



Dynamo No. 1 Westinghouse DC generator tag (Anthony Guild, 2022)

Dynamo No. 2 GE generator tag (Anthony Guild, 2022)

Dynamo No. 2 is in the electrical room just aft of the superheater on the main deck. Dynamo No. 2 is a General Electric 18.4 kW generator assembly manufactured by GE. The prime move for this dynamo is a vertical single short stroke high-speed reciprocating steam engine. The engine has a 9 x 7 (presumed inches) bore and stroke. Installation date is not known.

Shore Power

Electric power to the *Eureka* is provided via a shore power cable to the ship. Presently the cable is connected to the bow of the vessel through an electrical plug. Power is provided to the ship from the shore power through a large A/B selector switch that at one time allowed for power to be fed from the bow or the stern depending on the mooring arrangement. The A/B switch is located above the main switchboard and can only be accessed from climbing up the walking beam A-frame. From the A/B switch power is fed through three isolation transformers and then to a main distribution panel.

Shore power isolation transformers (Anthony Guild, 2022)

The isolation transformers were installed prior to 1992 to isolate the electrical system and to prevent galvanic or stray current corrosion.

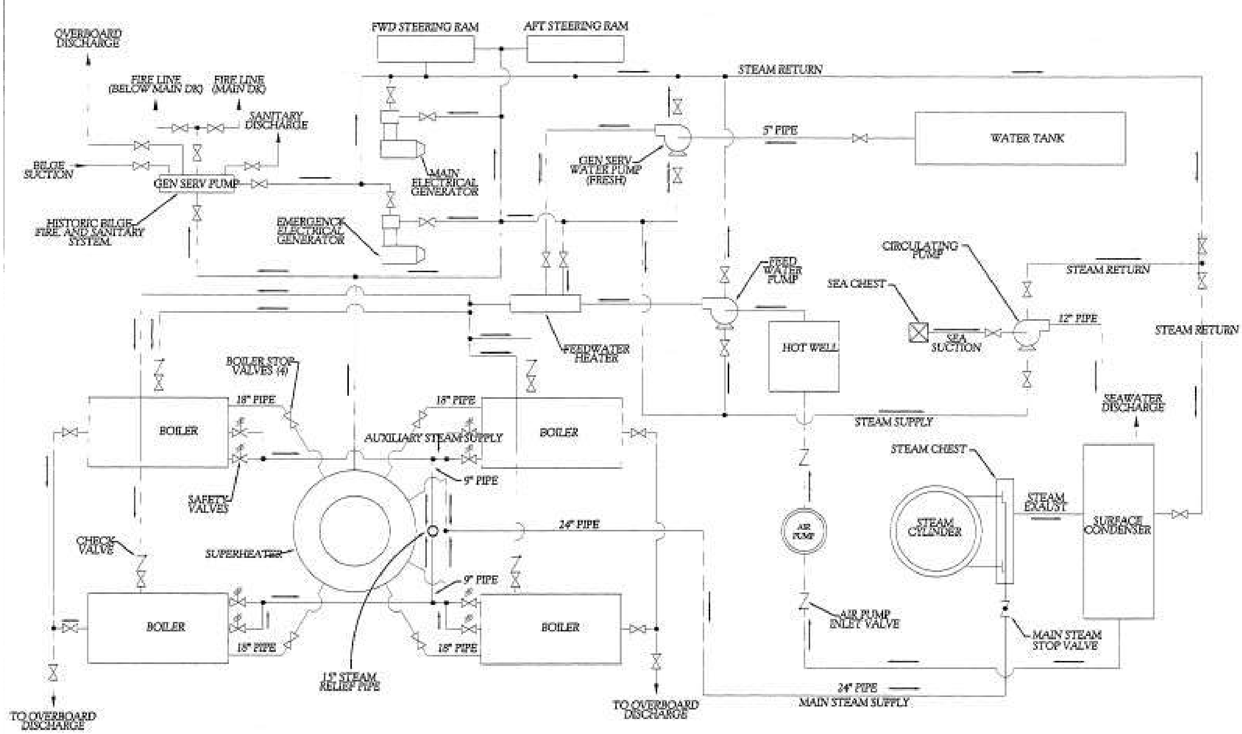
Main DC Switchboard

The vessel's DC electrical switchboard is located on the car deck just forward of Dynamo No. 2 inside the machinery enclosure. Access to this location is through a heavy-duty metal screen steel door from the starboard side of the vessel. The DC switchboard is no longer in service. It has been covered in clear plastic and is illuminated so the switchboard equipment can be viewed from the car deck. The original brass knife switches that were used to turn the ship's DC electrical equipment on and off are visible. An AC panel board is located immediately forward of the DC switchboard.

DC Electrical Switchboard (Anthony Guild, 2022)

PIPING SYSTEM AND COMPONENTS

There is a considerable amount of piping used in the various systems on board the *Eureka*. The range of piping materials



Steam piping configuration (Eureka HAER documentation by Tri-Coastal, 1990)

on the vessel reflect the different eras in which the vessel operated. Much piping is original while some is more recent, such as the PVC bilge/dewatering piping system.

Steam Piping System

Steam piping runs throughout the vessel to all the steam driven machinery. Piping components to the fuel service pumps and steam fuel heat exchanger are missing.

Car Deck Sprinkler System

A sprinkler firefighting system was installed at the car deck at an unknown date. The system was powered by the main steam driven fire pump. The piping is plumbed throughout the overhead on the car deck and consists of a pipe perforated with small holes that point down. The piping

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Section Six

Evaluation of Significance

EVALUATION

The historical significance of the *Eureka* was recognized in 1973 when the vessel was listed on the National Register of Historic Places, and again in 1985 when it was designated as a National Historic Landmark. The *Eureka* was found to be significant in the areas of industry, technology, commerce, engineering, and transportation, with a broadly assigned period of significance including the nineteenth and twentieth centuries.[101] The statement of significance developed in the 1984 National Register nomination assigns the *Eureka* national significance based on the vessel's type and the vessel's association with a wide range of transportation systems as they developed across the United States during the span of a century from the early 1800's to the mid-1950's.[102] The nomination describes *Eureka* as the last intact wooden hulled side wheel steamer afloat in the continental United States, and nationally significant as an example of the type of wooden paddle steamers that led to this country's inland waterborne commerce into the industrial era.[103]

The National Register nomination also describes *Eureka*'s walking beam engine as intact and largely unaltered since its manufacture in 1890, and assigns the vessel national significance in the fields of industry, technology, and engineering as the only example of such a marine engine left operable and afloat in North America.[104] Additional national significance was found in the field of transportation, since the vessel has been associated with a range of travel from horses, steam trains, interurban electric railways and automobiles.[105] The National Register nomination describes the *Eureka* as a representative of a fleet of vessels which completed a crucial trans-bay transportation link, and thus significantly altered the Bay Area's demography.[106]

Based on the research completed for this report, the *Eureka* remains historically significant for the reasons developed in the 1984 National Register of Historic Places Inventory Nomination Form. However, in light of the contemporary rubric for the evaluation of historic significance established by the National Park Service in the 1990s and detailed in *National Register Bulletin 20: Nominating Historic Vessels and Shipwrecks to the National Register of Historic Places*, the language of the findings should be revised, and architecture should be added to its existing areas of significance.[107]

The vessel is historically significant under National Register Criterion A (Event) because it is associated with events that have made a significant contribution to the broad patterns of our history, under the theme of transportation, as a ferry boat which transported commuting passengers between San Francisco and Marin County, contributing to the suburban settlement of Marin County; and under the themes of commerce and industry, as a ferry boat which transported rail cars and associated freight, and later automobiles and general freight. The period of significance for both findings of significance under Criterion A is 1890,

[101] While commerce is checked as an "area of significance" in the National Register Nomination Form, significance in this area is not developed in the statement of significance. Similarly, while significance in the field of industry is developed in the statement of significance, it is not checked as an "area of significance" in the National Register Nomination Form.
[102] Haller, Eureka *National Register Form*, Section 8, Page 1.
[103] Haller, Eureka *National Register Form*, Section 8, Page 1.
[104] Haller, Eureka *National Register Form*, Section 8, Page 1.

[105] Haller, Eureka *National Register Form*,, Section 8, Page 1.
[106] Haller, Eureka *National Register Form*, Section 8, Page 2.
[107] James P. Delgado and National Park Service Maritime Task Force, *National Register Bulletin 20: Nominating Historic Vessels and Shipwrecks to the National Register of Historic Places*, U. S. Department of the Interior, National Park Service, Washington, DC, 1992.

the year the vessel was constructed, through 1957, the year the vessel ceased ferrying passengers and freight.

The vessel is also historically significant under National Register Criterion C (Design/Construction) in the category of architecture, because it is a good representative example, and the only known remaining example, of a specific type of naval architecture, namely the wood-hulled, side-paddlewheel, steam-powered ferry, a type of vessel that contributed to inland waterborne commerce in the era of U. S. industrialization. The period of significance under Criterion C in the category of architecture begins in 1890 when the vessel was constructed, through 1957, the year the vessel ceased ferrying passengers and freight.

The vessel is also historically significant under National Register Criterion C (Design/Construction) in the category of engineering because the vessel retains its original walking beam engine, manufactured by Fulton Iron Works in San Francisco and installed when the vessel was constructed in 1890. The walking beam engine in the *Eureka* is good representative example of an engine type once common in ferryboats and is now the only known walking beam marine steam engine afloat. The period of significance under Criterion C in the category of engineering begins in 1890 when the walking beam engine and its affiliated components were installed, and ends in 1914, the year the coal burning boilers that originally powered the engine were removed and and replaced with oil fired boilers.

INTEGRITY

Integrity refers to the ability of a property to convey its historic significance in relation to its period of significance, generally achieved by the retention of some or all of seven aspects including location, design, setting, materials, workmanship, feeling, and association.

The *Eureka* retains integrity of location because the vessel is moored in a location with which it has a historical association, namely San Francisco, the city where the vessel's runs started and ended. While the vessel most typically berthed at the Ferry Building, the *Eureka* made some landings at Hyde Street Pier after 1929, where the ship is now moored. The *Eureka* also retains integrity of setting because the vessel is maintained in the water.

Regarding integrity of design, materials, and workmanship, guidance from the National Park Service indicates that a vessel is expected to undergo change throughout its active life, often to a greater degree than buildings on land due to the corrosive nature of the marine environment. When changes are made to a vessel in the effort to repair, renew or replace damaged materials, and these changes are made with materials and methods that in composition, design, color, texture, and workmanship retain the historic character of the vessel, these changes generally do not affect a vessel's integrity of design, materials or workmanship.

Components of the vessel that retain integrity of design, materials, and workmanship to the 1890 date of construction are limited to the wooden keel and the walking beam engine (including the 1914 replacement of boilers). Repairs, renewals, and replacement at the hull and walking beam engine have largely been made in kind or with limited and judicious use of modern materials such that these components still retain integrity to their original date of construction or installation.

The remaining components of the vessel, including the paddlewheels; main, passenger, and hurricane decks (including permanent fixtures); paddle boxes; engine and smokestack casing; the house; the A-frame that supports the walking beam; and the smokestack and whistles, do not retain integrity of design, materials, and workmanship to the 1890 date of construction, but do retain integrity of design, materials, and workmanship to 1922, when the vessel was substantially rebuilt.

The *Eureka* retains integrity of feeling, because the vessel retains significant physical characteristics to convey her

historic significance and evokes an aesthetic or historic sense of the past. And, finally, the *Eureka* retains integrity of association, because the vessel is displayed in the water, in a generally accurate waterfront setting, moored with a gangway for visitors to board the vessel at the bow, one of two historic boarding locations for the two-ended vessel.

In summary, the *Eureka* retains integrity of location, setting, feeling, and association; retains integrity of design, materials, and workmanship to its 1890 date of construction only at the keel and walking beam engine; and retains integrity of design, materials, and workmanship to its 1922 rebuild at all other components of the vessel.

CHARACTER-DEFINING FEATURES

A character-defining feature is an aspect of design, construction, or detail that is representative of a historic resource's function, type, or architectural style. Character-defining elements include the overall shape of the historic resource, its materials, craftsmanship, decorative details, interior spaces, and features, as well as the various aspects of the resource's site and environment. Character-defining features of the *Eureka* include:

- General specifications including length of 299' 6" at deck, beam of 78" at deck, and depth of 15' 7";
- Material components of the walking beam engine installed when the vessel was constructed (1890) or during the period of significance (1890-1957), including material components that have been replaced in kind after the end of the period of significance with limited and judicious use of modern materials (after 1958);
- Material components of the wood keel, hull, and paddle wheels installed when the vessel was constructed (1890) or during the period of significance (1890-1957), including material components that have been replaced in kind after the end of the period of significance with limited and judicious use of modern materials (after 1958);
- Material components of the vessel's house, inclusive of the stairs and windows, that were installed in 1922, when the vessel was substantially rebuilt, or prior to the end of the period of significance (1957), including material components that have been replaced in kind after the end of the period of significance with limited and judicious use of modern materials (after 1958);
- Material components of the main deck, inclusive of the decking and sheathing, rolling wood panel doors, engine casing, paddle boxes, posts, girders, and assorted smaller features that were installed in 1922, when the vessel was substantially rebuilt, or prior to the end of the period of significance (1957), including material components that have been replaced in kind after the end of the period of significance with limited and judicious use of modern materials (after 1958);
- Open spatial arrangement of the main deck, generally expressed as two open "aisles" from end to end of the vessel, reflecting the vessel's historic use as constructed in 1890 as a railroad ferry, and after being converted from a railroad ferry to a double-ended automobile ferry in 1922;
- Material components of the passenger deck, inclusive of the decking and canvas covering; sliding wood doors; combination metal and bent wood bench seating; posts, girders, ornament at brackets and moldings, and assorted smaller features that were installed in 1922, when the vessel was substantially rebuilt, or prior to the end of the period of significance (1957), including material components that have been replaced in kind after the end of the period of significance with limited and judicious use of modern materials (after 1958);
- Spatial arrangement of the passenger deck largely characterized by rows of seating arranged along aisles, smaller rooms above and adjacent to the paddle boxes and engine casings, and lofted central bay with clerestory windows, reflecting the vessel's historic use as a passenger ferry;
- Material components of the hurricane and dome

deck that were installed in 1922, when the vessel was substantially rebuilt, or prior to the end of the period of significance (1957), including material components that have been replaced in kind after the end of the period of significance with limited and judicious use of modern materials (after 1958);

- Spatial arrangement of the hurricane and dome deck largely characterized by open space, reflecting the historic use by crew only of this area of the vessel;
- Location, profile, and material components of the pilothouses that were installed in 1922, when the vessel was substantially rebuilt, or prior to the end of the period of significance (1957), including material components that have been replaced in kind after the end of the period of significance with limited and judicious use of modern materials (after 1958);
- Location, profile, and material components of the walking beam engine that project above the dome deck, including the riveted steel A-frame and the cast-iron walking beam, that were installed during the period of significance (1890-1957), including material components that have been replaced in kind after the end of the period of significance with limited and judicious use of modern materials (after 1958); and
- Location, profile, and material components of the fidley and smokestack, including the tripartite whistles that were installed in 1922, when the vessel was substantially rebuilt, or prior to the end of the period of significance (1957), including material components that have been replaced in kind after the end of the period of significance with limited and judicious use of modern materials (after 1958).

Section Seven

Condition Assessment

COMPREHENSIVE CONDITIONS SURVEY

Between November 15 and December 19, 2019, a comprehensive condition survey was completed on the *Eureka.* The results of that survey were documented in report titled Title I Preliminary Engineering Report - Ferryboat *Eureka* Critical Systems (2020).

That 73-page report provides an extensive overview on the condition of the *Eureka* from late 2019 and early 2020. It describes numerous structural components of the vessels that were and remain critically compromised. Considering the age and construction of the *Eureka*, the problems are severe, but not unexpected. Principally these concerns are related to corrosion of the vessel's mechanical fasteners, decay of the ship's timbers, and failure of the copper bottom, all of which leave the vessel's underwater body unprotected from worms and other wood eating parasites.

A Conditions Assessement is not in the body of this HSR as the 2020 survey report is provided in the appendices of this report.

SIGNIFICANT CHANGES ASSESSMENT

In late 2021, Maritime Technical Services again attended the vessel to report on any significant changes in the *Eureka's* condition since the previous survey in late 2019. The results of that assessment were recorded as an addendum to the 2020 report and are provided in the appendices of this report as well.

PEER REVIEW ASSESSMENTS

In mid-2022 a peer review was conducted of the initial 2020 Preliminary Engineering Report and the 2021 Addendum. The peer review supported the conclusions and findings of those surveys and is provided in the appendices of this report.

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Part 2: Treatment and Work Recommendations

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Section Eight

Historic Preservation Objectives

The *Eureka* is a National Historic Landmark and listed on the National Register of Historic Places. As such, it is important that all future work on the ship be carried out in accordance with The Secretary of the Interior's Standards for Historic Vessel Preservation Projects with Guidelines for Applying the Standards (the Standards). The Standards provide general information for stewards of historic vessels to determine appropriate treatments. They are intentionally broad in scope to apply to a wide range of circumstances and are designed to enhance the understanding of basic preservation principles. The Standards are neither technical nor prescriptive but are intended to promote responsible preservation practices that ensure continued protection of historic vessels.

The Standards include eight general standards, and then additional specific standards based on the appropriate treatment approach. There are five treatment approaches that may apply to the *Eureka* – protection, stabilization, preservation, rehabilitation and restoration – which are defined as follows:

Protection is the act or process of applying measures designed to affect the physical condition of a vessel by defending or guarding it from deterioration, loss, or attack, or to cover or shield the vessel from danger or injury. Such treatment is generally of a temporary nature and anticipates further historic preservation treatment.

Stabilization is the act or process of applying measures designed to arrest, retard, or prevent deterioration of a vessel, and to assure its structural integrity. This may include rendering the vessel weather resistant and watertight. The essential form of the vessel shall be maintained during this process.

Preservation is the act or process of applying measures necessary to sustain the existing form, integrity, and materials of a historic vessel.

Rehabilitation is the act or process of returning a vessel to a state of utility through repair or alterations that make possible an efficient contemporary use while preserving those features of the vessel that are significant to its historical, naval architectural, technological, or cultural values.

Restoration is the act or process of accurately recovering the form and details of a vessel as it appeared at a particular period of time by removal of later work, or by replacement of missing or substantially deteriorated earlier work.

There are also other key definitions that that also apply to the Eureka – historic fabric and reproduction – which are defined as follows:

Historic Fabric is the material remains of a historic vessel or object, whether original materials or material incorporated in a subsequent historically significant period.

Reproduction is the construction or fabrication of an approximate copy of an object and an object that is the result of such a process.[108]

Moving forward, individual projects may fall under varying treatment approaches once the restoration or rehabilitation work on the vessel is complete. For example, recurring maintenance activities may be approached as protection or stabilization, depending on the extent of work needed. Future treatment of elements already restored should

[108] *Michael Naab, The Secretary of the Interior's Standards for Historic Vessel Preservation Projects with Guidelines for Applying the Standards, (Washington D.C.: U.S. Department of the Interior, Office of the Secretary, National Park Service, National Maritime Initiative, 1990).*

generally follow a preservation approach, assuming the overall restoration work is successful.

In keeping with The Standards, interventions, structural improvements, and ongoing maintenance should be undertaken as necessary while minimizing the loss of historic fabric and retaining the existing form and appearance of the historic features. If possible, interventions should be designed to be reversible. Features should be thoroughly documented photographically before any work is undertaken in order to chronicle changes and to aid in reversing any alterations that become inappropriate in the future.

The *Eureka* should continue its current use as a museum and public interpretive site. In support of that use, improvements for visitor access and safety, as well as ongoing ship maintenance and repair, are recommended. The following sections, Requirements for Work and Work Recommendations and Alternatives, provide guidelines and recommendations for the continued restoration of the *Eureka*.

Section Nine

Requirements for Work

APPLICABLE CODES, LAWS, AND REGULATIONS

Different regulations may apply to the *Eureka* depending on its active use. This report assumes the ferryboat will be used as a building and evaluates its compliance with applicable building codes. When in active use as a vessel, maritime and United States Coast Guard (USCG) regulations would supersede building codes only when the vessel maintains an active Certificate of Inspection and is being inspected by USCG personnel. Some flexibility may be required to maintain compliance with both sets of regulations and switch between the two.

If evaluated as a building or structure, the *Eureka* would be considered an existing, historic structure. Compliance with prevailing building codes is not required for existing buildings, unless they undergo an addition, alteration, repair, or change in use, or if a code deficiency presents a distinct hazard to life safety.

In accordance with a Supreme Court Decision, the Coast Guard no longer inspects permanently moored craft or issues Certificates of Inspections to such craft unless a craft demonstrates that it is a vessel, capable of being used as a means of transportation on the water. The Federal Register dated May 11, 2009 discusses the implications of the Supreme Court decision and responds to comments received in response to a 2004 Federal Register notice that proposed a policy for permanently moored vessel.

Since the promulgation of the Craft Routinely Operated Dockside (C-ROD) Policy in May 2009, an estimated 21 passenger craft have been deemed permanently moored craft and determined not to meet the definition of vessel as defined in this policy. These craft ceased to be inspected by the Coast Guard and oversight was handed over to the appropriate state authorities.

According to the National Park Service Director's Order 28, historic structures are "generally expected to meet modern safety, access, and energy efficiency standards," but it is also understood that the character of the historic resource may limit the interventions that are acceptable. At the *Eureka*, there is an additional layer of interventions that may be limited to preserve functionality. The following preliminary analysis outlines the larger code, fire protection, life safety, and accessibility issues that exist at the ferryboat, with additional discussion where code compliance may not be feasible or prudent.

The current governing buildings codes for any proposed work include:

- 2021 International Building code (IBC)
- 2021 International Existing Building Code (IEBC)
- Additional codes, laws, and directives that may be applicable, depending on the scope of work, include:
- 2020 National Electrical Code (NEC) (NFPA 70)
- 2021 International Energy Conservation Code (IECC)
- 2021 International Fire Code
- 2015 Architectural Barriers Act (ABA) Standards
- Director's Order 28 (Cultural Resources Management)
- Director's Order 42 (Accessibility for Visitors)
- Director's Order 16A (Accessibility for Employees)
- Memorandum to Regional Directors and Park Superintendents: Disability Access in the National Park Service, 2006
- The National Historic Preservation Act

- The Secretary of the Interior's Standards for the Treatment of Historic Properties

The prevailing code, the IBC, prescribes solutions to conditions based on new construction models. When conformance with the IBC would adversely affect the historic character of a qualified historic structure, the IEBC may be invoked as a means to preserve historic fabric and explore solutions that meet the intent, but not necessarily the letter, of the prevailing codes. As *Eureka* is listed on the National Register and is designated as a National Historic Landmark, it is considered a historic resource under the IEBC and the provisions of IEBC Chapter 11 and IBC Chapter 34 may be used.

The California State Historic Building Code, (CHBC), may also be referenced, although it is not recognized as a Standard Code by the NPS. The CHBC is a performance-based code, which allows for alternative solutions to be considered in achieving the intended life-safety objectives of more prescriptive building codes in order to preserve historic features.

In addition to the IBC and IEBC, fire and life safety issues in the national parks are governed by the code of The National Fire Protection Association (NFPA). The primary NFPA code applicable to this building is NFPA 101, the Life Safety Code. Other NFPA codes to be considered include NFPA 70, the National Electric Code; NFPA 72, the National Fire Alarm Code; and NFPA 914, Code for Fire Protection in Historic Structures. Like the CHBC, NFPA 914 provides for performance-based approaches and operational solutions that meet the intent of NFPA 101 with the least impact on a building's historic character.

Although not a building code, the Architectural Barriers Act (ABA) is a federal civil rights law enacted in 1968 that governs disabled access to facilities designed, built, altered or leased with certain federal funds. In 2015, new design standards were released for new or altered facilities covered by the ABA. The 2015 ABA Accessibility Standards (ABAAS) have been used in this analysis.

CODE REQUIREMENTS

This section identifies requirements of the typical, prescriptive code measures identified at the beginning of this section. Where performance-based code alternatives may apply, the relevant code official must be engaged during the decision-making process. For example, the fire marshal having jurisdiction would need to approve any performance-based approach to fire protection measures.

Type of Construction

The *Eureka* is constructed of wood, which is considered a combustible material in the building code. As such, the ferryboat is best considered Type V-B construction. Type V is described in IBC Section 602.5 as "that type of construction in which the structural elements, exterior walls and interior walls are of any materials permitted by this code." Type V-A requires a 1-hour rated structural frame, while V-B requires no fire-resistance rating of any building elements. Type V-A buildings are sometimes referred to as "protected frame" buildings and typically achieve their required fire-resistance ratings by enclosing wood elements in noncombustible materials. Adding fire-resistant protection to the *Eureka* would be undesirable for historic preservation reasons. Accordingly, considering the vessel as Type V-B construction for this and future building code evaluations is recommended.

Occupancy Group

Chapter 3 of the IBC defines the different types of uses for each occupancy group. As a museum and interpretive site open to the public, the Eureka falls into the Assembly (A) occupancy group. The IBC further characterizes assembly occupancies by the density of the crowds to be expected in that use. Museums fall into the A-3 group.

Allowable Area and Height

The IBC dictates maximum building sizes based on

occupancy and type of construction. As a ferryboat, this requirement is not strictly applicable to the *Eureka*, but this analysis may help direct decisions relating to occupancy limits and exiting on board. As described above, the *Eureka* has an A-3 occupancy of Type V-B construction. Per Chapter 5 of the IBC, the structure is limited to one story with a maximum height of 40 feet and the maximum permitted area is 6000 square feet. If you consider the engine room deck, main car deck and passenger deck as the main interior floors and the enclosed pilothouse as a partial 4th story, the ship is not in compliance with the area requirements and exceeds one story. These requirements do not need to be met if the structure does not undergo a change in use. However, if the ship were to be equipped with an automatic fire sprinkler system throughout, the code limitation would increase to 2 stories.

Occupant Load and Egress Paths

Chapter 10 of the IBC establishes the number of allowable occupants in the building (the occupant load) based on the different building functions and the area of each within the building. The number of required exits and the required width for each exit path is then determined from the occupant loads being served.

All areas of the *Eureka* function as a museum, although the park could limit visitors to certain areas if desired. Museum and exhibit spaces have an occupant load of 30 net square feet per occupant. This results in an occupant load of 188 inside the engine deck, 363 on the car deck, 288 on the passenger deck and 24 total for both pilot houses. Spaces with an Assembly occupancy type and an occupant load (per story) from 50-500 are required to have two exits. With its single exit (gangplank), the *Eureka* currently does not comply, and occupancy must be limited.

A minimum level of illumination and exit signage is required for all exit paths. The illumination must be provided by lights connected to an emergency power system that will operate even if the main power fails. Lighting and exit signs are needed inside the hold if that space is used after dark.

Exit doors also have technical requirements for thresholds to reduce tripping hazards and maximum opening force limits to operate the door hardware. These issues should be evaluated more closely.

Human Safety (Egress)

As noted earlier in this section, the means of egress from the *Eureka* are inadequate based on the size of the ship (if evaluated as a building). With only one exit off the ship, occupancy onboard must be limited to 49 occupants.

If the *Eureka* is to continue functioning as a museum, it is recommended that a second means of egress be provided primarily for the purposes of increasing the occupancy capacity beyond 49. Entry/exits should be at opposite ends of the ship. The existing sliding gates on the passenger deck would ideally be used. The gates are currently not active and would need to be restored. Reinforcing of the deck may also be required to support a gangway.

Fire Protection

Upgrades to fire protection systems, including fire alarms and sprinklers, are not required by code if a building is not undergoing a change in use. Considering the all-wood structure and unique significance of the *Eureka*, voluntary fire protection measures may be warranted. Smoke detectors inside the hold, improved security onboard, and fire sprinkler systems inside the ferryboat enclosures, car deck and passenger deck are advised. For high risk areas where additional protection may be required, any additional penetrations should be limited and piping should be integrated or surface mounted to minimize visual impact to the ship's fabric.

Hazardous Materials Abatement

Considering there has not been extensive restoration completed over the lifetime of the vessel, hazardous materials are likely to remain in accessible locations at the *Eureka*. Lead paint does not need to be removed if the paint coating remains intact. If historic painted finishes may

be disturbed during future work, however, testing should be conducted to identify potential hazardous materials and determine an appropriate treatment of abatement or encasement.

Universal Accessibility

In addition to the governing codes, NPS Management Policies require all historic structures to provide the "highest feasible level of physical access to historic properties that is reasonable, consistent with the preservation of each property's significant historical features." Accessibility solutions need to be carefully weighed to evaluate impacts to historic materials, likely costs, and overall feasibility.

At a minimum, providing disabled access from the pier onto the deck will be challenging and require a custom designed solution. Disabled access can be provided via equivalent facilitation if physical modifications would create an adverse effect on a historic structure. Equivalent facilitation could include virtual tours, a physical model, or other methods of experiencing the *Eureka* from an accessible location.

Section Ten

Work Recommendations and Alternatives

TREATMENT AND USE RECOMMENDATIONS AND ALTERNATIVES

The following recommendations are based on conditions assessment, conditions observed during site visits and a series of meetings with park staff. As a floating structure, the *Eureka* is dependent on a strong and watertight hull. Condition assessments are clear that the *Eureka's* hull is at the end of its life with significant decay in the wood timber and advanced corrosion in the metallic fasteners which hold that timber together. If the *Eureka* is to provide another 100 years of historical relevance, the ongoing degradation of the hull must be addressed. While alterations are necessary to preserve the hull as well as improve access and visitor safety, care must be taken to ensure that character- defining features and the resource's historic integrity are preserved and intact.

The straightforward approach to stabilization and preservation of the *Eureka's* hull would be to drydock the vessel, replacing decayed timber and corroded fastenings as necessary. The nature of a complex wood structure like the *Eureka's* is that most joints and fastenings cannot be adequately inspected without disassembly. The onboard condition surveys and past *Wapama* and *C.A. Thayer* restoration projects suggest that to fully repair the hull would likely require almost complete dismantlement and the replacement of nearly all fasteners and much of the vessel's timber.

The scale of this type of repair requires considering alternatives. Three categories of alternatives have been considered. The first alternative is the complete reconstruction of the *Eureka's* hull using materials and methods that are as close to the existing hull as is possible. Second, the hull could be removed from the sea to prevent the corrosion and decay that comes from being immersed in seawater. Third, the hull of the *Eureka* could be reconstructed from an alternate material which would potentially be less costly to build and require less in-service maintenance. For a more complete discussion of these alternatives, see the National Park Service Memo in Appendix G.

ARCHITECTURAL MATERIAL CONSERVATION RECOMMENDATIONS

In December 2021 and January 2022, the National Park Service had meetings to discuss the existing hull condition of the *Eureka* and what alternatives could be considered for repairing or replacing the hull. It was recognized that the answer could have significant impacts on the historic fabric of the vessel as well as project costs. Three hull treatment alternatives were presented.

Alternative 1 - Replacement in Kind

Description:

Replacement of the *Eureka* hull with new material copying the original shapes, sizes, and methods of construction.

Discussion Summation:

Although replacement of the hull would not preserve original fabric, it would be a desirable option to preserve the historic character to the greatest extent possible as a replacement in-kind and protect the physical integrity of the vessel. It would also preserve the character and setting and allow the vessel to remain in water.

However, as a large wooden vessel, the *Eureka's* lift cycle costs would be vastly higher due to the maintenance required. With the procurement of full size lumber and the selecting of the best grades of wood needed for the laminated wood process, the waste generated from the fabrication process can mean that over two times the

timber will be needed to fabricate each replacement part. It should also be considered that reconstructing the hull out of wood will restart the process of deterioration. Due to the maintenance required, this will lead to another hull replacement in the future sooner than if other materials were used.

Alternative 2 - Removal from the Water

Description:

Remove the vessel from direct contact with open water permanently and preserve it as an object.

Discussion Summation:

Removing the vessel from water includes incasing the *Eureka* in concrete, placing the whole ship on a barge, as well as removing the topsides and putting them on dry land. This would greatly degrade the visitor experience and is less desirable from a historical preservation perspective as it turns a historical vessel into a museum piece that no longer is experienced in context as a vessel in the water.

Although there may seem to be benefits to this alternative to remove the vessel from the an environment that contributes to its deterioration, the *Eureka* faces several challenges if she were to be removed from water and placed on dry land. These include wood shrinkage, fastenings becoming loose, rain infiltration due to the hull being "opened" due to drying, and hull deformation.

In summary, removing the *Eureka* from water would do little to further the preservation of the vessel as the hull would likely need to be replaced and extensively reinforced. The costs associated with removing the vessel from the water permanently would likely be the most expensive alternate in terms of initial cost.

Alternative 3 - Recreate Hull with Non-historic Materials

Description:

Replacement of the hull in its entirely with new construction and materials, duplicating the shape, profile, and finished appearance of the original construction.

Discussion Summation:

The alternative would preserve the overall historic character and appearance to the greatest extent possible while balancing life cycle maintenance. While the outer hull may be a contemporary material, the inner hull should retain the wood construction in certain areas, including the engine room, so that the use of contemporary components should not be outwardly visible in these areas.

Replacing the exterior hull with steel while retaining wood on the interior would reduce long-term maintenance costs while preserving the historical character of the original hull would be notably reduced or lost. However, other significant features, such as the engine and the engine room, could be better preserved along with the ability to keep the vessel in-water. This alternative also preserves much of the interior historic character as much as possible, which would allow the physical integrity of the overall resource to continue.

Converting to a steel hull would end *Eureka's* designation as a wooden ship. Altering such a significant feature of the vessel warrants recognition and further discussion. Given her status as one of the largest, if not the largest, wooden floating structures in the world, this is an important consideration.

VALUE ANALYSIS

On January 10, 2022, the HSR team participated in a preliminary Value Analysis (VA) discussion for the Great American Outdoors Act funded project for the *Eureka*. Although the VA did not directly influence considerations for the HSR, it did provide an opportunity to further discuss the condition of the hull and the feasibility of the alternatives listed above.

The technical consultants reiterated that the hull condition is frail. A question addressed in discussion was whether areas of the hull not currently visible might ultimately be salvageable and if a decision on replacement could wait until such areas could be physically accessed and investigated. It was noted that achieving such access would require placing the vessel in dry dock and beginning disassembly. A specific challenge with this approach is that procurement for replacement material could not begin until the assessment is complete. Due to the challenges in sourcing and preparing material this process could take many months and likely over a year, a period during which the vessel would be sitting in dry dock at great expense and vulnerable to further deterioration.

- Regarding Alternative 1 – Replacement in Kind. Further specifics were discussed regarding the challenges to procuring wood for a full or partial hull replacement regardless, of replacement in-kind or selecting the laminate option. It is likely that high quality, old growth lumber is simply not available – the trees likely don't exist and even if they do exist, harvesting old growth trees could be questionable from a forest stewardship perspective. Lower quality wood would be more susceptible to deterioration. Acceptable lumber from newly felled trees cannot be selected until it has been properly seasoned, so replacements for rejected lumber would restart the procurement cycle. Given the schedule for funding, and the deteriorated state of the ship, there cannot be delays in material procurement.
- Regarding Alternative 2 – Removal from Water. This option was deemed unfeasible due to the challenges in securing a land-based location, the impacts to the vessel's materials and likely high costs. This alternative was considered and dismissed from the VA as the HSR team also felt that this was not an appropriate treatment for the vessel due to the removal from context and the likely deterioration of historic fabric.
- Regarding Alternative 3 – Recreate Hull with Non-historic Materials. It was noted that the definition of "hull" should be clarified. It does not necessarily mean the entire structure below the deck; the "outer hull" – planking, keel and framing, could be distinguished from the "inner hull" – ceiling, hanging knees, etc. It would be possible to replace the outer hull with non-historic materials and either retain or replace in kind portions of the inner hull.

CONCLUDING MEETING

Discussion:

Through the several months that the NPS HSR team discussed the future of the *Eureka*, and specifically the hull, the group repeatedly returned to their responsibility to attempt to retain historic fabric and form. The condition of the hull was revisited and unique sources for securing lumber were sought; however, viable preservation options remained elusive. In the context of *Eureka* and her deteriorated condition, the notion of "preserve to the greatest extent possible" is a challenging concept, and the team increasingly realized that some features would be saved while others would be lost.

Conclusions were not easily reached. Nearly all team members spoke to the difficulty of deciding whether to replace historic fabric. As the vessel was originally commissioned by the San Francisco and North Pacific Railroad as the ferryboat *Ukiah* and then reconstructed and renamed by Southern Pacific as the *Eureka,* the team

also discussed which timeframe the vessel would best represent. It was noted that the park has been in this position before when no action ultimately resulted in the loss of the *Wapama* and when a consideration to avoid historic fabric loss in the *C.A. Thayer* nearly prevented her restoration.

Recommendations:
The *Eureka* should be exhibited afloat in the water.

Although restoration of the wood hull does not seem feasible, it should not be ruled out if future resources and commitments can overcome the challenges identified in this report. However, given the challenges that have been identified, the general treatment would be Rehabilitation. If an alternative hull material is selected, it is recommended that the vessels wooden outer hull would be replaced with a more durable and easily maintained material. This alteration would accommodate the vessel's contemporary long-term use as a museum ship and would more accurately represent how it was last used as the Southern Pacific ferryboat, the *Eureka.* Rehabilitation is the option that best facilitates preservation of vessel as a whole, supports an achievable long-term maintenance program and provides a realistic haul-out cycle.

If pursued, a replacement hull should reflect the shape, profile, and finished appearance of the original construction including such features as the sponsons/outriggers that support the overhanging car deck and rudders. In general, the historic form and appearance of the hull should be maintained. While the outer hull maybe a contemporary material, the inner hull should retain the wood construction in certain areas, including in the engine room, as contemporary components should not be visible to the public in these areas.

The new hull needs to support the engine, boilers and related equipment without alteration to that equipment. It also needs to accommodate the activation of the walking beam and rotation of the paddles.

RESTAURANT AND CAFE

The current configuration of the restaurant/cafe of the *Eureka* is thought to have been done without compliance to the National Historic Preservation Act, Section 106. These non-historic materials and elements should be removed.

By reorienting this space to match its last known historic arrangement, this area will align with the surrounding Southern Pacific time period structural elements of the ship and reflect more accurately how it was last used. This truncated form of this area is visible in the HABS/HAER drawing (dated May 1990) of the passenger deck.

ACCESSIBILITY

Car Deck and Passenger Deck

The HSR team discussed ways to improve access for disabled visitors and ensure that they are able to enjoy as much of the historical experience as possible. At present, disabled visitors are able to board the *Eureka* via a gangway to the car deck level, but there is no accessibile route to the historic passenger seating areas that are a key part of the visitor experience. Providing access should be a primary goal if not a requirement.

One way to make the passenger deck accessible would be to install an internal elevator or lift. It is not yet clear where (or if) such an apparatus might be installed while still preserving the historic fabric and appearance of the vessel. Such an addition should contrast with the *Eureka's* historic fabric to make clear that it's a modern addition. The team plans to study further the possible installation of such a device and potential locations.

An alternative might be to construct a shoreside structure or an external tower on the pier that would provide ADA access to the main deck and passenger deck on the *Eureka.*

In summary, access to the passenger deck should be provided. The external tower concept is preferable, an internal elevator/lift is acceptable. The least visible and least impactful location for an internal elevator/lift should be sought and the device should clearly contrast with the historic fabric.

Hurricane Deck and Pilot Houses

As with all ships, the pilot house is one of the primary locations a visitor might want to experience as it is the "control center" of the ship. The pilot house is raised above the hurricane deck by several feet. This area is not accessible on the *Eureka* without significant impact on historic fabric and the appearance and character of the ship. There is no stairway upon which a platform lift could be installed and there are not internal spaces to conceal an elevator/lift on either the passenger or the hurricane decks. The pilot house and rooms behind it are too small to accommodate an internal elevator/lift as it would occupy nearly all, if not all, of the space.

Access via an external tower would result in a tower height and associated gangway to the deck that would significantly interfere with the appearance of the structure. Accommodating the weight of the gangway would require structural reinforcements of the deck that could not be concealed.

In summary, physical access to the hurricane deck and pilot house cannot be provided. It would require the addition of a new elevator/lift enclosure rising above the hurricane deck, affecting historic fabric, and dramatically altering the appearance of the vessel. A programmatic solution should be pursued for this area.

Engine and Engine Room

The engine room is only accessible by a very steep and narrow stairway and there is no location where a lift or elevator could be installed. Besides the problem of access, the engine room is also not large enough to be ADA compliant without dismantling the engine or its components. Such a solution would be detrimental to visitor experiences because the engine is a primary, if not the primary, feature of the vessel.

The HSR team discussed ways to possibly improve accessibility. One possibility might be to cut new openings in engine casing and install glass windows for viewing different perspectives of the walking beam. Removing decking and installing windows would enable visitors to see down into the engine room.

The HSR team discussed improving accessibility for visitors who cannot navigate the stairs. One possibility might be to cut new openings in engine casing and install glass windows for viewing different perspectives of the walking beam. Removing decking and installing windows would enable visitors to see down into the engine room.

Such work would have to be limited, with locations carefully selected, and all work reversible in order to prevent an adverse effect on the historic integrity of the vessel.

The engine extends through all three deck levels and is not limited to the lower hold engine room; the walking beam itself is above the dome deck. This is pertinent in that seeing the engine does not necessarily require being in the engine room (as being in the engine room only reveals a portion of the overall engine apparatus).

In summary, some areas of the decking and engine casing should be opened to increase visibility of the engine, though care should be taken to avoid an adverse effect. The engine or its components should not be disassembled to create access, but some slight modifications may be acceptable.

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Appendices

Appendix A

Expanded Chronology of Use and Physical Development with Citations

Citations which close with an asterisk indicate research conducted by SAFR Ranger Chris Edwards.

DATE	NOTE	CITATION
October 1889	Keel of *Ukiah* laid down at North Pacific Railway Yard in Tiburon, California. Vessel was designed by Patrick H. Tiernan and built by John Dickie. The vessel was fitted with a walking beam engine manufactured at Fulton Iron Works in San Francisco.	"Afloat and Ashore: The Steamer *Ukiah* Makes a Successful Trial Trip," *Daily Alta California*, December 28, 1890, 6.*
May 18, 1890	*Ukiah* launched on May 18, 1890. About 800 people attended the nighttime event which was lighted by bonfires and torches. At launching, the *Ukiah* was variously described as carrying either ten or fourteen rail cars and was valued at $164,000.	"Launch of the Ukiah," *San Francisco Examiner,* May 18, 1890, 3; Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Common; General Class, Floating; Number, Str *Ukiah,*" Series 4: Equipment Records, Box 4, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.*
December 27, 1890	*Ukiah* conducted trial trip as new vessel.	"Afloat and Ashore: The Steamer *Ukiah* Makes a Successful Trial Trip," *Daily Alta California*, December 28, 1890, 6.*
Ca. 1890s	Sometime after the vessel was launched, the original manual steering system that the *Ukiah* was constructed with was replaced by two double cylinder steering engines, designed by master mechanic John Bonner.	Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 12.

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October 18, 1900	*Ukiah* ran aground on Angel Island en route to San Francisco from Tiburon in a heavy nighttime fog. Damage was localized to a broken rudder and badly strained plates in the bow, and the vessel spent two weeks in drydock in Tiburon for repair.	"Ferry-Boat *Ukiah* Safe," *San Francisco Chronicle*, October 20, 1900, 14.
1906	Two original Flue Return Tubular coal-fired boilers were converted to oil-fired boilers.	Sixteenth Annual Report of the San Francisco and North Pacific Railway Co. for the Year Ending June 30, 1905, 30.*
1907	In 1906 the Southern Pacific and the Atchison, Topeka & Santa Fe railroads acquired and merged several dozen regional rail lines in Northern California to establish the Northwestern Pacific Railroad. The San Francisco and North Pacific Coast Railway was part of this merger, and in 1907 the *Ukiah* ceased direct service between San Francisco and Tiburon and instead began runs between San Francisco and Sausalito, the southern terminus of the new rail company's lines. Around this time, the hurricane deck of the *Ukiah* was modified to include passenger cabins, reflecting an increase in regular commuters as the residential neighborhoods of Marin County grew.	Lynn Cullivan, "1890-1990 *Eureka,* A Centennial Retrospective," *Sea Letter* (Journal of the National Maritime Museum Association), No. 42, Spring/Summer 1990, 31.
April 16, 1907	*Ukiah* sank while docked in San Francisco at the Lombard Street wharf. The vessel had been loaded with flat rail cars carrying gravel. The switching crew erred in unloading cars from only one side of the vessel; the vessel listed, took water through open portholes, and sank. Divers inspected the hull, sealed the portholes, pumped out, and towed to the Southern Pacific yard in Oakland for repairs.	"'Ukiah" Sinks in Her Slip," *Press Democrat* (Santa Rosa), April 17, 1907, 1; "Big Ferry Steamer Ukiah Sinks in Night at Wharf," *San Francisco Examiner*, April 17, 1907, 3*; "Car Steamer *Ukiah* Sinks at Her Slip," *San Francisco Call*, April 17, 1907, 11.

October 1911	Fractured cylinder head at the main engine replaced with new cylinder head.	Letter from Engineer B. Tuckey to U.S. Inspectors, Hulls and Boilers, October 12, 1911, HDC 648, Folder 4-Series 4, Harrison Dring Papers, *Eureka* Historical (1911-1985), Maritime Research Center, San Francisco Maritime National Historical Park.*
February 1912	Hull inspection report included the following information about the *Ukiah*: ▪ Required crew included one master/pilot, two mates, three deck hands, one chief engineer, one assistant engineer, two firemen, one watchman, seven stewards or similar not associated with operating the vessel; ▪ Two wooden watertight bulkheads; ▪ Two decks with permanent stairways; ▪ Two anchors with chain cable; ▪ Double steering gear (one set at each end of vessel) inclusive of wire tiller ropes and iron rod and chain; ▪ Wire bell pulls for engine room signals, and communication/voice tubes for communication between pilot houses and the engine room; and ▪ Four lifeboats.	Department of Commerce and Labor, Steamboat Inspection Service, Hull Inspector's Report, Steamer *Ukiah*, February 3, 1912, HDC 11, *Ukiah* (built 1890: ferry) inspection records, 1911-1912, Maritime Research Center, San Francisco Maritime National Historical Park.*
August 15, 1912	General repairs and maintenance were authorized for the *Ukiah*.	Northwestern Pacific Railroad Company – Mechanical Department, "Report of Progress on Important Work October 1912," Series 1: Office of Master Mechanic and Superintendent of Steamers / Mechanical Department Records, Box 1, MS 56 Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.*

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October 23, 1912	Four new boilers were authorized to be constructed for the *Ukiah*. Boilers were constructed by Seattle Construction and Dry Dock Company.	Northwestern Pacific Railroad Company, "Report of Progress on Important Work October, 1912," n.d; R. Damian Nance, "The Paddle Steamer *Eureka* and its Walking Beam Engine," *International Stationary Steam Engine Society Bulletin,* January 2018, 60.*
March 10, 1913	Construction of new boilers for *Ukiah* begun.	Northwestern Pacific Railroad Company, "Report of Progress on Important Work, March, 1913."*
March 12, 1913	Nineteen-day period of general repair and maintenance begun for *Ukiah*.	Northwestern Pacific Railroad Company – Mechanical Department, "Report of Progress on Important Work March, 1913," and "Steamer Service Report March, 1913," Series 1: Office of Master Mechanic and Superintendent of Steamers / Mechanical Department Records, Box 1, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.*
December 1913	Eleven-day period of repair.	"Steamer Service Report December, 1913," Series 1: Office of Master Mechanic and Superintendent of Steamers / Mechanical Department Records, Box 1, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.*

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March-April 1914	Fifty-one-day period of service and repair included installation of new boilers, renewal keelsons and other timber, special support for tracks carrying cars over the boilers, and renewal of fire and circulating pumps and piping.	"Steamer Service Report, March, 1914"; "Steamer Service Report, April, 1914"; "Increase and Decrease, March, 1914,"; "Increase and Decrease, April, 1914," and Northwestern Pacific Railroad Company – Mechanical Department, "Report of Progress on Important Work April, 1914," all held in Series 1: Office of Master Mechanic and Superintendent of Steamers / Mechanical Department Records, Box 1, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation on Statewide Museum Collections Center. Northwestern Pacific Railroad Company – Authority for Expenditure – Request No. 703, "Operating Expenses, Northwestern Pacific Railroad Company – Steamer *Ukiah*," Series 4: Authority for Expenditure/ Executive Authority Records, Box 7, MS 56 Northwestern Pacific Railroad Collection.*
July 1914	Four new boilers installed. Project cost was $16,546.19.	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Common; General Class, Floating; Number, Str *Ukiah,*" n.d.*
June 1915	Unspecified project related to compartments. Project cost was $762.58.	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Common; General Class, Floating; Number, Str *Ukiah*," n.d.*

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February-April 1916	Restaurant added to the hurricane deck of the *Ukiah*, as part of an effort to better accommodate automobile ferry users. New construction included a restaurant, ladies' cabin, smoking room, and additional toilets. Cost for new construction was $3,239.	Northwestern Pacific Railroad Company – Mechanical Department, "Report of Progress on Important Work, February, 1916" and "Report of Progress on Important Work, March & April, 1916," both in Series 1: Office of Master Mechanic and Superintendent of Steamers / Mechanical Department Records, Box 1, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center. Northwestern Pacific Railroad Company – Authority for Expenditure –Request No. 864– Gen Mgr's No. M-1684, "Operating Expenses, Northwestern Pacific Railroad Company – Steamer *Ukiah*," Series 4: Authority for Expenditure/Executive Authority Records, Box 7, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.*
March-April 1916	Work done on decking.	Northwestern Pacific Railroad Company – Mechanical Department, "Report of Progress on Important Work, June, 1916," Series 1: Office of Master Mechanic and Superintendent of Steamers / Mechanical Department Records, Box 1, MS 56 Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.*
March 17, 1916	Project authorized for new feed water heaters for *Ukiah*.	Northwestern Pacific Railroad Company, "Report of Progress on Important Work, April, 1916."*
August 30, 1916	New stairway added, location unknown.	Northwestern Pacific Railroad Company – Mechanical Department, "Report of Progress on Important Work, September, 1916," Series 1: Office of Master Mechanic and Superintendent of Steamers / Mechanical Department Records, Box 1, MS 56 Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.*

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January 1917	Carbide lamps purchased for onboard use. Cost was $9.54.	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Common; General Class, Floating; Number, Str *Ukiah*," n.d.*
February 1917	Stairway added at an unknown location, may be duplicate record for new stair in August 1916. Cost was $410.70.	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Common; General Class, Floating; Number, Str *Ukiah*," n.d.*
June 1917	Two fireroom ventilators added to the vessel. Cost was $74.66	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Common; General Class, Floating; Number, Str *Ukiah,*" n.d.*
April 1918	Feedwater heaters were added to the engine room. Cost was $1,476.10.	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Common; General Class, Floating; Number, Str *Ukiah,*" n.d.*
July 1919	Signs were added onboard, no further information. Cost was $43.97.	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Common; General Class, Floating; Number, Str *Ukiah,*" n.d.*
April 1920	Engine order telegraphs added to the pilot houses. Cost was $346.46.	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Common; General Class, Floating; Number, Str *Ukiah,*" n.d.*
June 1920	Oil meter to measure fuel consumption added to the engine room. Unknown if this was a replacement or new equipment. Cost was $72.37	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Common; General Class, Floating; Number, Str *Ukiah,*" n.d.*
July 1920	Handrails added to vessels' gangplanks. Cost was $22.24	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Common; General Class, Floating; Number, Str *Ukiah,*" n.d.*
January 29, 1921	Lights added to the vessel. Unknown if these were replacements or new equipment. Cost was $156.12.	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Common; General Class, Floating; Number, Str *Ukiah,*" n.d.*
April 17, 1921	Blueprint of the *Ukiah* shows general machinery layout in 1921, with two fuel tanks (one each directly aft of boilers 3 and 4) and three water tanks in the compartment immediately aft of the engine room.	Blueprint, Stmr *Ukiah*, Arrangement of Bulkheads, April 17, 1921, NW.P.R.R.Co., Office of G.S.M.P.&M.E., Tiburon, Calif., HDC 555, folder 34, *Ukiah* Plans 5 BP 3 Vellum (used for copies), Maritime Research Center, San Francisco Maritime National Historical Park.*

Ca. 1922	Following several years of hard use during World War I under the United States Railway Administration transporting railcars loaded with munitions, *Ukiah* was one of two Northwestern Pacific ferries chosen to be rebuilt. Work was undertaken at the Southern Pacific Shipyard in Oakland. The name change to *Eureka* was announced while work was underway in January, 1922. Trials were being run by March 11. Around 200 men were involved in the rebuilding effort.	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Passenger and Automobile, General Class, Floating Equipment, Number, Steamer *Eureka*," Series 4, Equipment Records, Box 4, MS 56; Northwestern Pacific Railroad Company, Executive Authority - No. 1406 - A.F.E. No. M-3660, "Authority is requested for the following expenditure for account of Steamer *Eureka* (*Ukiah*): Reconstruction," Series 4, Authority for Expenditure/ Executive Authority Records, Box 7, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center; Blueprint, Indicator Cards Str. Eureka, Oakland, Cal., March 13, 1922, HDC 555, drw B4.24-1, Maritime Research Center, SAFR. "Examiner Marine Exchange: Ferryboat Renamed," *San Francisco Examiner*, January 26, 1922, 17.* Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka,* prepared for the San Francisco Maritime National Historical Park," San Francisco, 1990, 14; *Eureka* Scrapbook, Maritime Research Center, San Francisco Maritime National Historical Park.*
Ca. 1922	Following an accident on the ferry *Sausalito* wherein the black color of the walking beam was blamed for overlooked forging flaws, white replaced black as the customary paint color for walking beams, including at the rebuilt *Eureka*.	R. Damian Nance, "The Paddle Steamer *Eureka* and its Walking Beam Engine," *International Stationary Steam Engine Society Bulletin*, January 2018, 54.

March 11, 1922	Rebuilt *Eureka* made a trial trip and recorded the following physical specifications: ▪ Official Number: 25279 ▪ Rig: Side-Wheel Steamer ▪ Gross Tonnage: 2,420.00 ▪ Net Tonnage: 1,500.00 ▪ Length: 299' 6" ▪ Depth: 15' 7" Engine specifications were as follows: ▪ Cylinder Diameter: 65 inches ▪ Stroke: 12 feet ▪ Gauge Pressure: 55psi ▪ Vacuum: 27.5 inches ▪ RPM: 20.5 ▪ Spring: 24 ▪ Total Indicated Horsepower: 1844.6	Merchant Vessels of the United States, 1922; Blueprint, Indicator Cards Str. *Eureka*, Oakland, Cal., March 13, 1922, HDC 555, drw B4.24-1, Maritime Research Center, San Francisco Maritime National Historical Park.*
April 1, 1922	Rebuild of *Ukiah*, presumed to have begun around April 1921, was complete and vessel was renamed *Eureka*. Scope of work was described as such: "Complete reconstruction of steamer *Ukiah*, freight car and automobile transfer boat, into automobile and passenger carrying ferry steamer; name changed to *Eureka*. Tracks and entire housing removed; complete reconstruction and lengthening of hull (90% new timber used); wooden engine keelsons and gallows frame replaced with steel; engines, boilers and auxiliaries repaired and re-installed; hull recovered and caulked; superstructure and cabins entirely new construction; large restaurant facilities provided on saloon deck. Changes and additions necessary to provide facilities for the increasing automobile and passenger business. Renewal of hull, frames and other timbers requested by United States Local Steamboat Inspectors." Total estimated cost of work was $508,091.13.	Northwestern Pacific Railroad Company, "Record of Equipment - Kind, Passenger and Automobile; General Class, Floating Equipment, Number, Steamer Eureka," Series 4, Equipment Records, Box 4, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center; Northwestern Pacific Railroad Company, Executive Authority - No. 1406 - A.F.E. No. M-3660, "Authority is requested for the following expenditure for account of Steamer *Eureka* (*Ukiah*): Reconstruction," Series 4, Authority for Expenditure/Executive Authority Records, Box 7, MS 56, Northwestern Pacific Railroad Collection.* "Examiner Marine Exchange: Ferryboat Renamed," *San Francisco Examiner*, January 26, 1922, 17. "Tri Coastal Marine Inc., Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 14.

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Ca. 1922-1926	Photographic evidence shows that sometime during the years 1922-1926, the jackstaffs originally mounted on either side of the main deck, on both ends of the vessel, were removed and replaced with a single jackstaff mounted on centerline at each end of the passenger deck.	Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 15.
March 1923	1200-gallon water supply tank was added to the vessel (may have been potable water tank or a new feed tank). Cost was $629.98.	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Passenger and Automobile; General Class, Floating Equipment; Number, Steamer *Eureka*," n.d.*
August 1923	Pantograph gates were added at main deck. Cost was $638.12.	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Passenger and Automobile; General Class, Floating Equipment; Number, Steamer *Eureka*," n.d.*
December 1923	Walking beam link pin broke and was repaired.	San Francisco Maritime National Historical Park, Resource Management records, Harry Dring Photographs, 1870-1983, Box 15.*
May 1924	Approved annual inspections and repairs included replacement of 869 sheets of "yellow metal" (copper), and one wooden main deck beam was replaced with a metal section where it passed through the engine's eccentric rods; approval document states this replacement was ordered by U.S. Inspectors. Total cost with minor repairs and painting was $6,000.	Northwestern Pacific Railroad Company, Executive Authority - No. 1596 - A.F.E. No. M-4162, "Authority is requested for the following expenditure for account of Steamer *Eureka*: Annual inspection and repairs," Series 4: Authority for Expenditure/ Executive Authority Records, Box 8, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.*

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September 1924	Additional seating installed on the main deck, described as such: "Installation of seats on main deck, forward and aft, which will provide additional seating capacity for approximately 227 passengers, such seats being required for the heavy passenger trips. Seating capacity of Steamer *Eureka*, on main deck, was originally limited, on account of projected use of this boat for automobile service. Seats have been found insufficient to take care of the peak load of commuters, and weekend passenger travel. The additional seats will be of the same type as the others on the main deck, i.e., removable when desired to use the boat in exclusive automobile service." The estimated cost for this was $585.	Northwestern Pacific Railroad Company, Executive Authority - No. 1627 - A.F.E. No. M-4255, "Authority is requested for the following expenditure for account of Steamer - *Eureka*: Additional seats on main deck," Series 4: Authority for Expenditure/ Executive Authority Records, Box 9, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.*
February 1925	Approval for seasonal repairs included docking, cleaning, and painting hull, renewing yellow metal (copper) where necessary, and annual inspection. The estimated cost was $5,536.	Northwestern Pacific Railroad Company, Executive Authority - No. 1662 - A.F.E. No. M-4372, "Authority is requested for the following expenditure for account of Steamer *Eureka*: Repairs," Series 4: Authority for Expenditure/Executive Authority Records, Box 9, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.*
December 1925	*Eureka* damaged in an accident. Paddlewheel shaft broke and was repaired.	Northwestern Pacific Railroad Company, Executive Authority - No. 1781 - A.F.E. No. M-4643, "Authority is requested for the following expenditure for account of Steamer *Eureka*: Annual inspection and repairs," Series 4: Authority for Expenditure/Executive Authority Records, Box 9, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.* Tri Coastal Marine Inc., Draft Historic Structure Report for *Eureka*, prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 15.

January 1926	Steel outboard bearing beam was added at the starboard side, replacing a wooden beam, believed to be the outboard support for one of the paddle wheels.	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Passenger and Automobile; General Class, Floating Equipment; Number, Steamer *Eureka*" n.d.*
March 1926	Approval for seasonal repairs included docking, cleaning hull, renewal of approximately 1,000 sheets of yellow metal (copper), repairs to fender, boilers, engines, lavatory, restaurant and galley, and renewal of main deck sheathing and painting where necessary. Estimated cost was $11,500.	Northwestern Pacific Railroad Company, Executive Authority - No. 1778 - A.F.E. No. M-4636, "Authority is requested for the following expenditure for account of Steamers *Eureka* and *Tamalpais*: Annual inspection and repairs," Series 4: Authority for Expenditure/Executive Authority Records, Box 9, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.*
June-July 1926	Attachment between the walking beam and crank pin broke during regular service. Newly constructed walking beam was installed at Moore Dry Dock Co. Size of some parts of the main engine including main rod and cross head that form the connection from the piston rod to the walking beam are increased.	(San Francisco) *Shipping Register*, June 12, 1926, 10. San Francisco Maritime National Historical Park, Resource Management records, Harry Dring Photographs, 1870-1983, Box 15.*
1927	Drydock at Moore Drydock Co. in Oakland. Celeron was applied to copper sheathing.	San Francisco Maritime National Historical Park, Resource Management records, Harry Dring Photographs, 1870-1983, Box 15. Northwestern Pacific Railroad Company, Executive Authority - No. 1860 - A.F.E. No. M-4863, "Authority is requested for the following expenditure for account of Steamer *Eureka*: Repairs," Series 4: Authority for Expenditure/Executive Authority Records, Box 9, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center. Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Passenger and Automobile; General Class, Floating Equipment; Number, Steamer Eureka" n.d.*

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February 1928	Approval for annual inspection by U. S. Inspectors for drydock to clean the hull, renew yellow metal (copper) and make general repairs. Estimated cost was $6,888.	Northwestern Pacific Railroad Company, Executive Authority - No. 1996 - A.F.E. No. M-5200, "Authority is requested for the following expenditure for account of Steamer *Eureka*: Annual inspection and repairs," Series 4: Authority for Expenditure/ Executive Authority Records, Box 9, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.*
August 1928	Women's smoking room was added at passenger deck. Cost was $264.25.	Northwestern Pacific Railroad Company, "Record of Equipment - Kind, Passenger and Automobile; General Class, Floating Equipment; Number, Steamer *Eureka,*" n.d.*
January 1929	Crack was discovered on walking beam strap, vessel was taken out of service for immediate repairs. Work also included general operating repairs, repairs to the paddlewheels, and tube renewal in all boilers. Estimated cost was $13,000.	Northwestern Pacific Railroad Company, Executive Authority - No. 2112 - A.F.E. No. M-5457, "Authority is requested for the following expenditure for account of Steamer *Eureka*: - Operating repairs," Series 4: Authority for Expenditure/ Executive Authority Records, Box 8, MS 56, Northwestern Pacific Railroad Collection, California Department of Parks and Recreation Statewide Museum Collections Center.*
November 1929	Improved lighting was installed.	Northwestern Pacific Railroad Company, "Record of Equipment – Kind, Passenger and Automobile; General Class, Floating Equipment; Number, Steamer *Eureka*," n.d.*
January 19, 1932	*Eureka* collided with steam schooner *Katherine* in heavy fog near the Ferry Building; damage did not sink either vessel or cause any loss of life.	San Francisco Maritime National Historical Park and San Francisco Maritime Museum Association, *A Brief Chronology of San Francisco Bay Ferryboat History, Draft II*, San Francisco, 1990, no page.
1933	Walking beam strap cracked.	San Francisco Maritime National Historical Park, Resource Management records, Harry Dring Photographs, 1870-1983, Box 15.*

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1933	The vessel's original jet condenser, which sat atop the bed plate immediately beneath the cylinder, was replaced by a surface condenser, positioned below and behind the valve gear.	R. Damian Nance, "The Paddle Steamer *Eureka* and its Walking Beam Engine," *International Stationary Steam Engine Society Bulletin*, January 2018, 60.
1934	Starboard paddlewheel shaft broke at inboard face of inboard wheel flange.	San Francisco Maritime National Historical Park, Resource Management records, Harry Dring Photographs, 1870-1983, Box 15.*
September 19, 1936	*Eureka* was struck amidships on the starboard side by the ferryboat *Golden West*. The accident occurred in heavy fog near Alcatraz Island. One passenger suffered a head injury. *Eureka* was towed to Sausalito with severe damage to a 40' section of the starboard side.	San Francisco Maritime National Historical Park and San Francisco Maritime Museum Association, *A Brief Chronology of San Francisco Bay Ferryboat History, Draft II*, San Francisco, 1990, no page; "Damaged in Crash off Alcatraz," *San Francisco Chronicle*, September 20, 1936, 8.
Ca. 1936-1957	Oral history data indicates that sometime after 1936, large glass windows which separated the smoking room from the starboard side promenade on the passenger deck were removed. The swinging doors into the smoking room, which appear in construction drawings from 1922, were also removed.	Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 16.
August 1937	LUX firefighting system was installed. This was a carbon dioxide firefighting system for use aboard ships and was invented and patented by Walter Kidde and Company, Inc. Blueprints show two banks of gas cylinders along the aft bulkhead and piping running through the length and at several points athwart the engine/boiler room along the bilges. Most of this system was removed at some point in the vessel's museum period.	Blueprint, LUX System, Diagrammatic Piping Layout, S.S. *Eureka*, HDC 555, drw, B4.24-3, *Eureka* Plans Details, 2 BP 1937-1938, Maritime Research Center, San Francisco Maritime National Historical Park.*
March 1, 1941	*Eureka* completed last day of Marin County ferry service; was immediately reassigned to service between the San Francisco Ferry Building and the Oakland Mole, transporting Southern Pacific passengers to and from the company's cross-country rail terminal.	"A Ferry Bids Farewell to its Old Friends," *San Francisco Chronicle*, March 2, 1941, 70.

Ca. 1941	Sometime after being placed in service on the Southern Pacific route between Oakland and San Francisco, the original restaurant at the forward end of the passenger deck was removed. Portions of the exterior of the vessel were repainted to read Southern Pacific. Some information exists to indicate that a smaller "snack bar" was installed behind the engine room casing bulkhead, though further verification would be required prior to any interpretive efforts to recreate such a snack bar.	Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 16. Chris Edwards, SAFR Ranger, "*Eureka* Physical Chronology," 2020.*
Ca. 1941	*Eureka* was painted grey and fitted with stanchions and cables to deflect mines. *Eureka* spent war years moving shipyard workers between San Francisco and Richmond, and troops from Camp Stoneman in Pittsburg, California to the Port of Embarkation at Fort Mason.	Mark R. Porter, "Addendum to Historic American Engineering Record, Ferry *Eureka*, HAER No. CA-59," San Francisco, CA, 2001, 25.
January 1943	*Eureka* was struck by incoming liner and sustained significant damage 55' back of the bow (no side reported). No injuries were reported. Thet ferry berthed at a slip at the Oakland Mole, where Southern Pacific officials reported repairs would cost around $25,000 and take several weeks.	"The *Eureka* Ferry Rammed by Liner in Heavy Bay Fog," *San Francisco Chronicle*, January 13, 1943, 15.
Ca. 1948-1953	*Eureka* was one of the growing number of civilian vessels on San Francisco Bay to be fitted with radar.	Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 17.

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1953-1954	*Eureka* entered drydock on October 16, 1953 for repairs at Moore Dry Dock Company in Oakland, California. The work was completed on May 19, 1954. The total cost was more than $600,000. Repairs to engines and boilers were as follows: repairs to boilers and boiler valves; repairs to main engine crank, bearings and crank pin; repairs to crosshead; repairs to lower steam chest; repairs to condenser and replacement of 1,700 condenser tubes; repairs to main fire pump and circulator; repairs to two steering engines; repairs to the electric generator; and repairs to paddle wheels. Repairs to the hull were as follows: removed and replaced all copper sheathing between waterline and the turn of bilge, about 125' on each side of hull; removed hull planking in above areas and replaced; applied heavy coats of wood preservative to new wood; removed entire inside ceiling between boiler room and engine room bulkhead to staggered butts, reinstalled new as per original; painted all areas disturbed; furnished and drove in new galvanized grommeted spikes; on Oakland end refastened every plank port and starboard from waterline to keel; removed and replaced main deck pointer on Oakland end; removed and replaced deteriorated futtock timbers; installed twenty-six natural knees and thirty timber knees; and, replaced four 70' keelsons in engine room and boiler room and four boiler bearers 62' long.	Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 17-18.

	Additional repairs were as follows: repairs to rudder; repairs to main switchboard; replacement of some main deck sheathing with 1" x 4" clear cedar; renewal of steering sheaves and troughs; removal of entire tongue and groove engine room floor and replacement with new flooring; installed new angle bars, handrails and replaced approximately 10% of boiler room floor plating with new diamond plate; and, replaced wood bulkheads at the fore and aft ends of the engine room with steel watertight bulkheads.	
1955	Smoke density indicator was installed to reduce fuel consumption and smog.	Authority for Expenditure, Southern Pacific Company, General Manager's No. 60695, Office of Genl. Supt. Of Motive Power, Genl. Superintendent's M.P. No. 35446, "Install a Smoke-Density Indicator and Alarm to one of our ferry steamers. AA-2501 approved Jan. 27, 1955," HDC 648, Folder 5 Series-4, Harrison Dring Papers, Repairs to Ferry Steamer "*Eureka*" 2/55 – 12/56, Maritime Research Center, San Francisco Maritime National Historical Park, and Mailgram (Noted on bottom left hand corner), Feb. 14, 1955, from B.M. Brown to R. Ersepke-West Oakland, "...regarding test application of smoke density detector and alarm on ferry steamer *Eureka*: Now have authority to proceed," HDC 648, Folder 5 Series-4, Harrison Dring Papers, Repairs to Ferry Steamer *Eureka* 2/55 – 12/56, Maritime Research Center, San Francisco Maritime National Historical Park.*

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April 1955	Due to rough water on bay, *Eureka* was reported to have suffered damage. Exact damage was unreported, but both pilothouses and superstructure needed repairs and re-sheathing needed to be removed to assess the area of the accident damage.	Mailgram, May 9, 1955, from B.M. Brown to R.E. Hallawell, "… regarding damage to the steamer *Eureka* account of rough seas experienced on April 25:…," HDC 648, Folder 5 Series-4, Harrison Dring Papers, Repairs to Ferry Steamer "*Eureka*" 2/55 – 12/56, Maritime Research Center, San Francisco Maritime National Historical Park.*
November-December 1955	Based on information in several memos from this time regarding heavy black smoke produced by the *Eureka*, evidence indicates that fuel system heaters in the fuel tank and under the fuel pumps were installed in the vessel in 1956; further research needed to confirm this theory.	Letter, Nov. 29, 1955, S.M. Houston to R. Ersepke, concerning *Eureka* smoking heavily, and Letter, Dec. 6, 1955, R. Ersepke to S.M. Houston, concerning heavy black smoke on ferry *Eureka*, HDC 648, Folder 5 Series-4, Harrison Dring Papers, Repairs to Ferry Steamer "*Eureka*" 2/55 – 12/56, Maritime Research Center, San Francisco Maritime National Historical Park.*
February 25, 1957	Crank pin broke and the vessel was towed to the Oakland Mole, rather than a shipyard. No repairs were made, and the vessel permanently left service.	Mark R. Porter, "Addendum to Historic American Engineering Record, Ferry *Eureka*, HAER No. CA-59," San Francisco, CA, 2001, 25.
1957-1958	Several months after the *Eureka* was taken out of service, Southern Pacific offered the vessel to the San Francisco Maritime Museum. The donation was accepted with the understanding that the vessel would be turned over to the State of California to join the state-owned vessels that would be displayed at the new San Francisco Maritime State Historic Park at Hyde Street Pier. Before the transfer could be exchanged, the San Francisco Maritime Museum owned the *Eureka* for more than a year, and carefully transported the vessel to an abandoned ferry slip at the Richmond-San Rafael ferry terminal. Title of the vessel was transferred to the State of California in 1958.	Karl Kortum, "Why I Picked the *Eureka*," *Sea Letter* (Journal of the National Maritime Museum Association), No. 42, Spring/Summer 1990, 34.

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March-June 1960	*Eureka* enters drydock at Bethlehem Steel Company's Shipbuilding Division yard in San Francisco on March 25, 1960. Work was completed on June 15, 1960. Cost was $13,985. The vessel received extensive bottom maintenance including as follows: repaired and renewed several worm damaged bottom planks; replaced all damaged copper sheathing on bottom, stem, sternpost, and rudders with new copper bedded in tarred Irish felt; repaired worm damage in rudders; and, cleaned and coated steel paddle wheel rims.	San Francisco Maritime National Historical Park, Resource Management records, Harry Dring Photographs, 1870-1983, Box 15; Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 18-19.
1960-1963	*Eureka* was berthed at Oakland Dock and Warehouse Co. for repair and preparation for display as a museum vessel. Restoration took three years and was supervised by Karl Kortum and Harry Dring. Work was financed by the tideland oil revenues managed and distributed by the State Division of Beaches and Parks.Known work completed during this period included the following: San Francisco Maritime State Historic Park maintenance personnel installed an electric jacking motor for turning over the main engine (1960); San Francisco Maritime State Historic Park maintenance personnel modified restrooms and plumbing, and installed a sewage holding tank and associated plumbing to enable visitors and staff to use of the historic rest rooms (1962); Malott and Peterson Roofing Company of Berkeley renewed the roofing and floor coverings (1963); and, a collection of historic automobiles was placed on the main deck for interpretive purposes (1962-1963).	San Francisco Maritime National Historical Park, Resource Management records, Harry Dring Photographs, 1870-1983, Box 15; Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 19.
Ca. 1960-1968	Between 1960 and 1968, the window frames on most of the clerestory windows were repaired and/or replaced. Some original etched glass panes were replaced with plain glass.	Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 19.

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October 2, 1963	*Eureka* was moved from Oakland to Hyde Street Pier in advance of the dedication and partial opening of the San Francisco Maritime State Historic Park.	San Francisco Maritime National Historical Park [photograph], Museum Number Catalog: SAFR 21374
1964	San Francisco Maritime State Historic Park maintenance personnel completed the following alterations and repairs: fire hose, axe racks, and lifering boxes were repaired or replaced; crew's locker room and washroom in Hold 5 were reactivated; pipe handrails were reinstalled; heavy rubber treads were installed on stairways and landings; the snack bar installed ca. 1941 was removed and new linoleum installed; and, sixteen blocks for boat falls were made and installed by master rigger Jack Dickerhoff.	Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 19-20.
1965	*Eureka* was drydocked at the Willamette Iron and Steel Company in Richmond, California. Following inspection of areas of the vessel's hull below the waterline, various portions of the hull were recoppered and new Irish felt installed. Additional work included "rebuilding of damaged Gypsy heads," presumably existing hand winches on either end of the main deck. Total cost was $42,836.00	Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 19-20.
1965	Repairs were made to hurricane deck, including replacement of rotten tongue and groove deck planking, rebuilding of handrails, and replacement of the four access ladders between the passenger and hurricane decks, to facilitate visitor access to the hurricane deck and pilot houses. Original access ladders were vertical and were located near the lifeboat stations.	Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 19-20.
January-June 1966	"Offshore" pilothouse restored and outfitted for public access and interpretation. Extent of restoration work completed is not fully understood due to limited documentation of the project.	Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 20.

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1973	*Eureka* was drydocked for cyclical maintenance and repair at Willamette Iron and Steel Company in Richmond, California, including routine bottom cleaning, installation of bottom sheathing, and repairs to women's restroom, deck capstan, steam whistles, and funnel guy wires. Cost of work was $64,917.00.	Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 20.
1978-1979	*Eureka* was drydocked for cyclical maintenance and repair at Todd Shipyard in Alameda, California. Maintenance included removal and replacement of fourteen sheets of plywood sheathing, bottom painting, exterior painting, and miscellaneous routine items. Repair was made to the foundation of the steel paddle box on the port side. The 7" x 14" x 45' sill timber beneath the paddle box was replaced, and the wasted lower edge of the steel paddle box bulkhead was repaired with a welded steel angle. Cost of work was $98,000. While in drydock, additional work was authorized for repair of a 32' section of rubrail on the starboard side. Work included replacement of the wood components of the rubrail, and renewal of the steel chafing plate along the outboard side of the rail. Cost of additional work was $5,523	Tri Coastal Marine Inc., "Draft Historic Structure Report for *Eureka*," prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990, 20-21.
1982-1983	Partial seat and molding cover replacement at *Eureka*, including birch veneer panels and metal flashing to match original.	San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 001.
1983	Lumber was procured for *Eureka* deck repair from Intermountain-Orient Inc.	San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 002.
1983-1987	Deck replacement was completed by Bay Ship and Yacht Company.	San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 003

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1984-1985	*Eureka* was drydocked at Triple A Shipyard in San Francisco for maintenance and repair. Scope of work included cleaning all marine growth from the hull, removing and replacing sample of plywood sheathing for hull plank inspection, replacing beams and stringers in the way of the lifeboat and davits on the starboard quarter, and replacing 920 square feet of canvas covered tongue and groove decking. Additional scope of work covered renewal of deck beams and conjunctive repairs, and repairs to copper sheathing, caulking of hull, doubler on bottom, and repairs to sea chest openings.	San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 005.
1988	30,000 linear feet of Alaskan Yellow Cedar or Port Ordford Cedar was purchased for repairs to *Eureka*, from American River Lumber Company, Inc.	San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 007.
1988-1990	Roof replacement and repair included reroofing the dome deck, installing roofing at men's and women's restrooms at the hurricane deck, and additional repair at roofing and decking using accurate replacement measurements and techniques. Work was completed by ECO (US).	San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 008.
1989-1990	Repairs made to and coating of the smokestack and the walking beam. Work was completed by Pacific Drydock and Repair Company. Smokestack and associated assembly were removed by crane barge and transported to Pacific Drydock's Oakland yard. The fidley apron was refabricated during this work as it was discovered to be largely unsalvageable.	San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 011.

1993-1994	Drydock period for hull repair and coating. Scope of work included exterior hull repair with specified repairs and removals; refastening below the water line with specified removal and replacement of deteriorated hull-planking spikes; renewal to rubrail, deck beam, and spring beam; hull cleaning and painting, with surface preparation and coating of hull; repairs to the main deck; manufacture and install replacement bearing beams; open and inspect designated sea suction valves; refastening planking to the hull; support beam repair, with extensive deterioration found in the support beam; additional rubrail components, with extensive deterioration found in the rubrail; copper removal from hull and keel and installation; deck repairs to the fan ends (aprons) and support structure due to extensive deterioration; and upgrades to electrical services. Work was completed by San Francisco Drydock Inc. Cost was $2,861,841.	San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 18.
1994-1995	Electrical and lighting repairs completed by Abbett Electric Corporation.	San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 19.

1999-2000	Drydock period for repair. Scope of work included hull cleaning; inspection and replacement of damaged planking; replacement of damaged copper sheathing; repair of main deck and rotten wood in hull; clean and overhaul sea suction valves including sea strainers, block and check valves, and painting the hull. Work completed under a modification of the original contract included fabrication of several dozen new windows due to excessive rot, installation of two hawse pipes, restoration of both paddlewheels (fabricate and install angle iron bracing) and paddlewheel houses, and additional replacement of sheathing fore and aft port and starboard main deck and passenger deck. Work was completed by San Francisco Drydock Inc.	San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 40 and 43.
Ca. late 1990s-early 2000s	Park staff undertook modifications to the Southern Pacific restaurant space.	Christopher Edwards, SAFR Park Ranger, "*Eureka* HSR – 75% Draft – Review Comments – Supplemental Information," 2022.
1998-2001	Construction of the gangway and access ramp for the *Eureka* included timber pier construction, minor utility relocation, and design and construction of a steel access bridge to the vessel. Work was completed by Vortex Diving, Inc.	San Francisco Maritime National Historical Park, Resource Management records, *Eureka*, HDC 1609, Series 4.06, File 41.
1999	Electrical system was rehabilitated.	National Park Service Project Management Information System Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.
2000	Kingposts were rehabilitated to correct structural failure.	National Park Service Project Management Information System Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.
No date (ca. 2001)	Asbestos abatement was completed at insulation on major structures including pipes, boilers, and machinery. Outer encasement (likely tin or canvas) portion of the steam chimney (plenum chamber) covering asbestos insulation was removed and not likely to have been saved.	National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*, compiled by SAFR 2021; Christopher Edwards, SAFR Park Ranger, "*Eureka* HSR – 75% Draft – Review Comments – Supplemental Information," 2022.

2004	Completed preparation and painting of the undersides of the overhanging passenger decks.	National Park Service Project Management Information System Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.
2005	Completed repair and replacement of the curved windows of the offshore pilothouse.	National Park Service Staff-completed Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.
2006	Completed rehabilitation of the mechanical system and painting the overhead and bulkheads in the engine room.	National Park Service Project Management Information System Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.
2008	Completed in-kind replacement of window sash on port main deck furthest forward.	National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.
2009	Completed replacement in-kind of deck edge stringer timber of the after overhang section of the hurricane deck. The new material was scarf-jointed into the ends of the sound existing material, and strongly bolted, executed in original type techniques and materials. Additional work included repairs to the area next to and forward of the port side lifeboat, with decorative fascia boards and molding removed for work; repairs to passenger deck covering boards and removable rails; and replacement of deteriorated fir sections using cedar for durability. Work was completed by Marine Carpenter Charter Kays. Budget estimate was $17,468.00. An additional scope of work included additional repairs to the fire sprinkler system to resolve deficiencies, with five sprinkler heads replaced and properly positioned; repairs to a leaking pipe; repairs to counterweight; painting and mooring maintenance; emergency repair using temporary patching to stop valve leakage through hull opening; and permanent fabrication and installation of cofferdam over the through hull opening.	National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*, compiled by SAFR 2021; National Park Service Project Management Information System Work Log, Ferryboat *Eureka*, compiled by SAFR 2021; National Park Service Staff-completed Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.

2010	Completed painting and finish work of the deteriorating, lead based coatings on the overhead and bulkhead surfaces of the passenger deck interior, with intent to encapsulate (paint) specified interior surfaces in order to seal existing lead-based coatings, prevent deterioration, and protect the vessel from the marine environment. Work was completed at the entirety of the overhead surfaces and the vertical bulkheads and fixed structures. Work included removal of old loose and flaking paint by hand sanding, hand scraping or other hand tools or by a combination of these methods appropriate to removing paint from wooden surfaces and delicate trim. All surfaces were cleaned by wiping down with water. Paint material was applied evenly. Molding, trim, ornaments, edges, lap seams, and millwork was completed with no excess paint in corners or depressions. Edges and lap seams of paint adjoining other materials or colors weere completed sharp and clean, without overlaps. An additional scope of work included application of Varnish/Paraffin/Solvent (VPS) blend to the wooden decks at the ends of the car decks, outside of the deck doors on both ends of the vessel. Decks were cleaned with deck brushes and flowing salt water, then household mops and a bleach solution. Decks then received penetrating coats of VPS applied by hand with mops or brushes. Other work included emergency gangway repair, kiosk wiring, painting, and mooring maintenance.	National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*, compiled by SAFR 2021; National Park Service Staff-completed Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.

2011	Completed repair work to the covering board and windows; removal of the pipe and wire railing from the starboard-aft hurricane deck; patterned, demolished, and replaced in kind the covering board from the paddle wheel housing to past the inboard curve by the pilot house; repaired and re-installed the pipe railing and renewed the wire line with new seizings and coatings; replaced the wire line on the port side pipe railing to match the starboard. Demolition and renewal of sash and window framing on at least one port side window. Removal of the stack guy wires and renewal the coatings and seizings and return renewed as found condition. Repaired the passenger deck, including repair to two banks of lights above the benches, both port and starboard sides of the offshore end; removal of five non-historic heaters; repair and installation of ornamental glass light fixture covers over seats; and installation of an override switch for the motion detectors which control lighting. Recoated tops of wheelhouses with elastomeric over non-historic synthetic mesh. Surface was washed with soap, water and brushes, and the coating was applied by roller. Outside portion of passenger deck surface recoated with oil-based enamel. Window trim and covering boards recoated as needed with water-based enamel. Oil treatment applied to unpainted wooden surface of main deck. Repainted exterior of the spring beam in water-based enamel. Missing portions of the metal handrail were reinstalled using original knob hardware and new steel piping. Exterior benches and railings were repainted as required in water-based enamel. Pine tar was applied to wire rope guy wires of funnel.	National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*, compiled by SAFR 2021; National Park Service Staff-completed Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.

	Elastomeric paint applied to davit deck; repairs completed to benches at passenger viewdeck and offshore deck; repaired passenger deck outboard rails; installed safety wire rail; repaired door of wheelhouse; repaired rolling door; rehabilitated sliding doors; window repaired, repaired ladder to foreward pilothouse; prepared and painted bulwarks and furniture at passenger viewdeck; completed general painting; and completed mooring and gangway maintenance.	
2012	Repaired one damaged non-historic ladder at forward hurricane deck and replaced another used for public and employee access. Repaired damaged portions of the ladder and/or replaced in-kind. Rebuilt after starboard hurricane deck ladder with twelve properly spaced steps and handrails extended beyond the last riser at the bottom of the stair flight. Completed handrail repair; bench repair at passenger viewdeck and offshore deck; car deck stanchions repair; and electrical repairs. Installed high volume pump. Nailed threshold plates at pilot houses. Completed repair to offshore pilot house. Plugged scupper; completed linoleum repair; repaired pump; repaired generator housing; repaired seawater suction valve; repaired outer mooring; stabilized rubr rails; installed new handrails on offshore dome deck; repaired sole in Junior's hold (#5); installed canvas skirts under benches; and painted dome deck and trim.	National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*, compiled by SAFR 2021; National Park Service Staff-completed Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.

2013	Work was completed by marine construction company to permanently plug leaking suction valve penetrating the hull in the area of the engine room. Work covered removing a metal grating (strainer), inserting a plug or "bung," and filling the opening with an epoxy pillow, compound, or lead sheeting. Repairs completed to shore up after car deck in the area of the stair box, which had lost structural integrity due to rotting of horizontal deck beams. Temporary vertical stanchions (shores) were attached to temporary dual strong backs and sister beams. Repair secured the deck and stair box and prevented increasing deformation of the deck and loss of deck camber. This stabilization was intermediate. No demolition or destruction of historic fabric was indicated. Work was located in Hold 6 which is accessed from Hold 5 and from a hatch in the vicinity of the capstan. Repair copmleted to tongue and groove sole in Hold 5 which suffered from local areas of rot. Nonhistorical lockers and furniture removed, focused demolition completed and replacement in kind of the sole along with the addition of supporting stanchions under the sole frame. The project included thorough preservation treatments, including Sodium Borate applications.	National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*, compiled by SAFR 2021; National Park Service Staff-completed Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.

Additional work included routine cyclic maintenance, including preparing and coating weather decks with elastomeric paint in kind with existing; preparing and painting wooden exterior covering boards and trim features; preparing and painting as necessary deck furniture and stairway boxes and stairs in red oxide to match original; preparing and painting as necessary vertical outdoor bulkheads to match original; preparing and coating canvas decks with suitable oil-based marine acrylic paint to match existing; treating, priming, and painting mooring chains to prevent corrosion and staining; cleaning and borate treating the wooden car deck; and borate treating wooden framing in lower holds and bilge areas.

An additional scope of work included gangway repair, including smokestack cap removal; painting at passenger view deck; repairing and painting at port side; refastening cardeck; repairing windows; bench repair; repairing areas of covering board and railing; repairing dome deck; stanchion installation; painting bulkheads at exterior of passenger deck; painting canvas deck; painting passenger deck; and painting the exterior of the wheelhouse.

Expanded Chronology of Use and Physical Development with Citations

2014	At the off-shore wheelhouse, work included documentation and survey of the cabin; demolition of non-historic fabric/furniture; stabilization and repair of rotted framing; repair/replacement in kind of rotted windows and frames; removal of carpeting and sub-flooring; paint and coating analysis; removal of unattached components to secure location. Further work included patterning and demolishing covering board; installing deck plate hardware at the engine room; installing gangway apron; replacing electrical box; and demolishing non-historic furnishings in offshore pilothouse.	National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*, compiled by SAFR 2021; National Park Service Staff-completed Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.
2015	Work completed to install a counterweight system to hold the vessel firmly in berth and mitigate the detrimental impacts caused by wave and wind action and tidal fluctuations on the vessel. The counterweight and sheave were installed between two existing 24"diameter steel piles that support the vessel's gangway, at same elevation of existing vessel hawse pipe at the mid-tide. Counterweight was attached by way of chain attached to the mooring chain and through a hawse pipe to mooring points on the vessel. Counterweight is removable to permit the repair of the system components and for the vessel to be taken from her berth. Additional work included routine preservation maintenance activities including painting inboard surfaces; adjusting moorings; cleaning including fresh water and soft brush on exterior surfaces, sweep and vacuum on interior; replacement of offshore cradle components; pest removal including racoon barriers; plywood panels fastened to historic fabric; resetting wedges for support posts at the aft hold; and repairing a leak in the hurricane deck.	National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*, compiled by SAFR 2021; National Park Service Staff-completed Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.

2016	Completed work included replacement of fluorescent light bulbs on car deck, passenger deck, and engine spaces with LED bulbs that match historic incandescent light color as close as possible. Additional work included adjusting moorings; refastening loose wear deck planking; replacing bilge pump; replacing bow fender tire; replacing strongback and decking at port aft mooring cleat; stabilizing the port bow; applying elastomeric paint to dome and hurricane deck; and replacing chafing gear.	National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*, compiled by SAFR 2021; National Park Service Staff-completed Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.
2017	Completed work included replacement of smokestack cap, which was lost to wind in 2013. The original steel cap was reproduced in aluminum and painted black. The new cap was secured to the ship at turnbuckles via stain-less wire as a subtitute for original steel chain. Additional work included adding a stern line; repairing hurricane deck beam; repairs at the passenger deck to bench and handrails; repairs at he hurricane deck to ladders and a leak; in-stallation of bilge pumps; repair to onshore pilot house deck beam and ladder; replacing chafe gear; painting the flag staff, metal ring frame, and stanchions; repairing the flagpole; and strik-ing the flagpole.	National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*, compiled by SAFR 2021; National Park Service Staff-completed Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.

2018	Completed work included replacement of stud-link chains that hold vessel to the mooring pilings at Hyde Street Pier; tasks related to providing safe public access to the engine room, including installation of five metal safety stanchions and attached rope/netting for the control platform (unmounted and stored down in the engine room by the lockers in the aft port corner of the space when not in use); repairing handrails at passenger deck; repairing starboard boat davit; replacing fender at port bow; preparing and painting lifeboat; refinishing outside passenger decks; repairing and painting the aft pilot house; and adjusting moorings.	National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*, compiled by SAFR 2021; National Park Service Staff-completed Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.
2019	Completed work included restoration of paint and wood at the shoreside of the car and passenger decks, including the stairs; large scale scraping and sanding; fabrication of new bench components, newel post, and post base trim; and building back up the coatings to a tight envelope on all surfaces. Additional work included repairing cover board Dutchman; repairing benches including milling wood and installation; painting the dome deck and pilot house; painting the davit area; painting the passenger deck; painting metal pipes; painting rails, coverboards, and gates; and painting stairway and stair kicks.	National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*, compiled by SAFR 2021; National Park Service Staff-completed Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.
2020	Completed work included repairs to the railing at passenger deck; repairs to weather offshore davit area; replacing Dutchman for cover board; replacing mooring chain; and replacing a pilot-house window.	National Park Service Staff-completed Work Log, Ferryboat *Eureka*, compiled by SAFR 2021.

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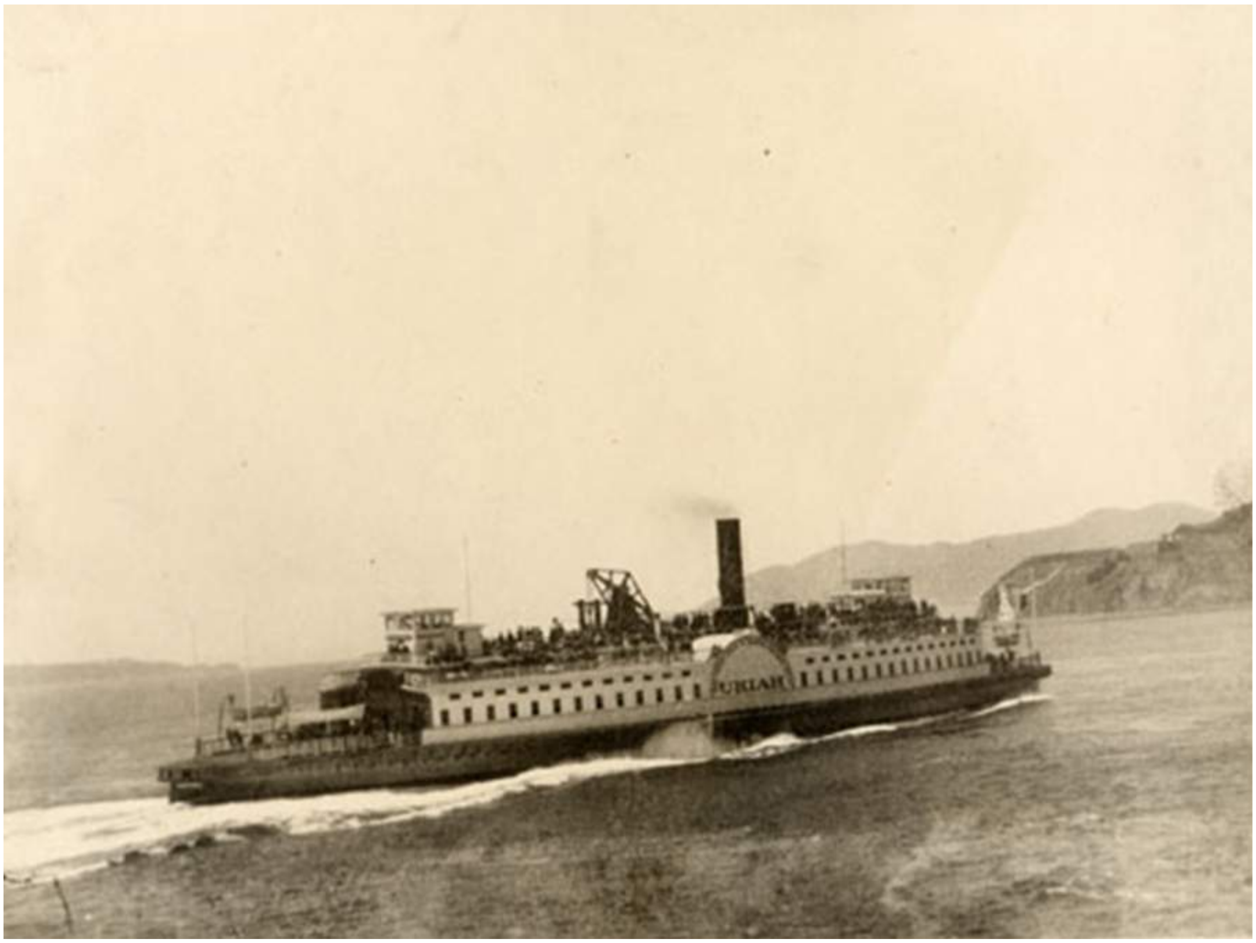
Appendix B

Historic Photographs

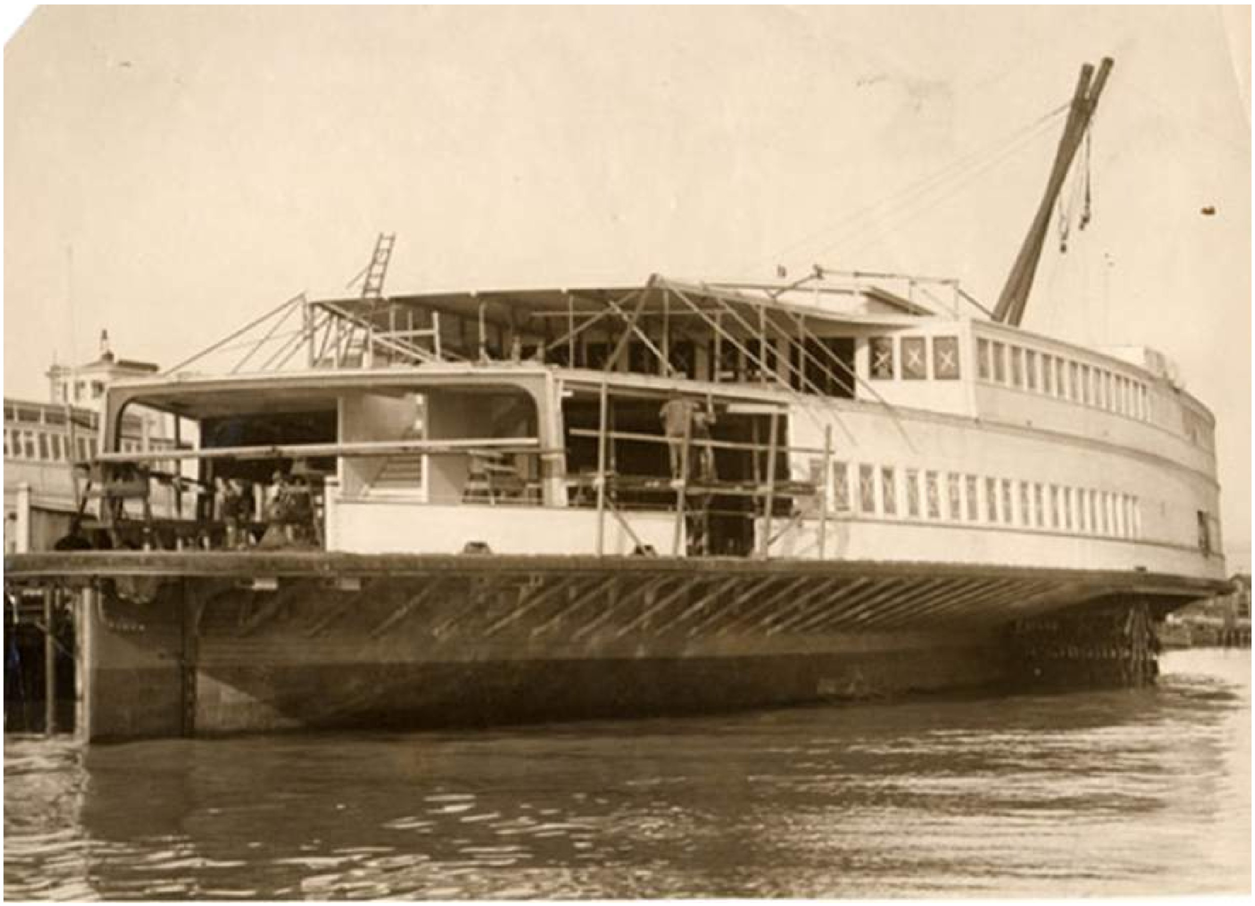
Paddle steamers including ferry Paul Pry at Broadway Street wharf, 1866
(San Francisco Maritime National Historical Park [SAFR], Catalog ID no. SAFR 21374)

Historic Photographs

The Eureka*'s walking beam engine with A-frame support, exposed during rebuild ca. 1921 (SAFR, Catalog ID no. SAFR 21374)*



Ukiah steaming to Tiburon, 1894
(San Francisco Public Library [SFPL] Historical Photograph Collection, ID no. AAH-0282)



Eureka under construction in Oakland, ca. 1921
(SFPL Historical Photograph Collection, ID no. AAH-0213)

Celebrants on the final scheduled ferry passage of the Eureka, 1941
(SFPL Historical Photograph Collection, ID no. AAH-0216)

Historic Photographs

Eureka arriving in San Francisco with passengers and freight, 1953
(SAFR, Catalog ID no. SAFR 21374)

Ford Model A being loaded on to the Eureka, 1962
(SAFR, Catalog ID no. SAFR 09318)

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Appendix C

Existing Condition Photographs

All photographs were taken by ARG, 2021 or by Anthony Guild, 2021 and 2022.

Aft starboard portion of the house

Fore starboard portion of the house

Midship sponson, rubrail, and paddlewheel

Existing Condition Photographs

Exterior bow end of main (car) deck showing stair to passenger deck

Exterior bow end of main deck showing rolling wood-paneled doors

Interior of main deck, stern end, showing passenger seating

Interior of main deck, bow end showing car display and passenger seating

Interior of main deck, midship showing engine casing (left) and paddlebox (right)

Interior of main deck, midship, showing paddlebox

Interior of main deck, midship, showing aft wall of the engine casing and access to the control room

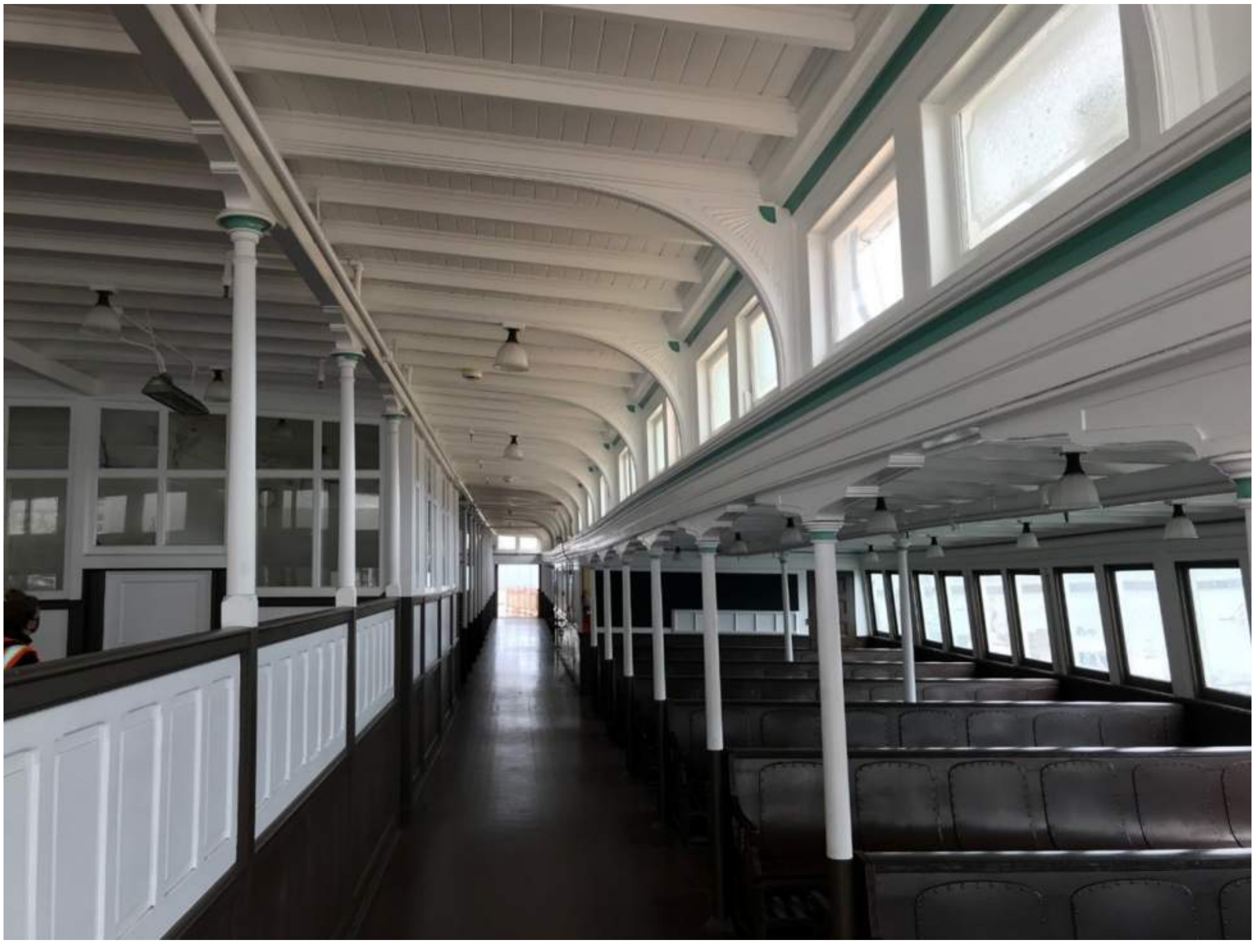
Existing Condition Photographs

Exterior stern end of passenger deck

Exterior bow end of passenger deck, showing lifeboat area and davits

Exterior bow end of passenger deck showing seating and storage area

Existing Condition Photographs



Interior port side of passenger deck

Interior fore portion of passenger deck showing former location of restaurant dining area (left) and galley (right)

Passenger deck seating detail

Interior passenger deck, midship starboard paneled enclosure, location of restrooms and storage

Interior passenger deck, aft of midship riveted steel engine casing

Starboard hurricane and dome decks

Dome deck midship, detail of riveted steel A-frame and cast-iron walking beam

Dome deck fore of midship, detail of fiddley and smokestack

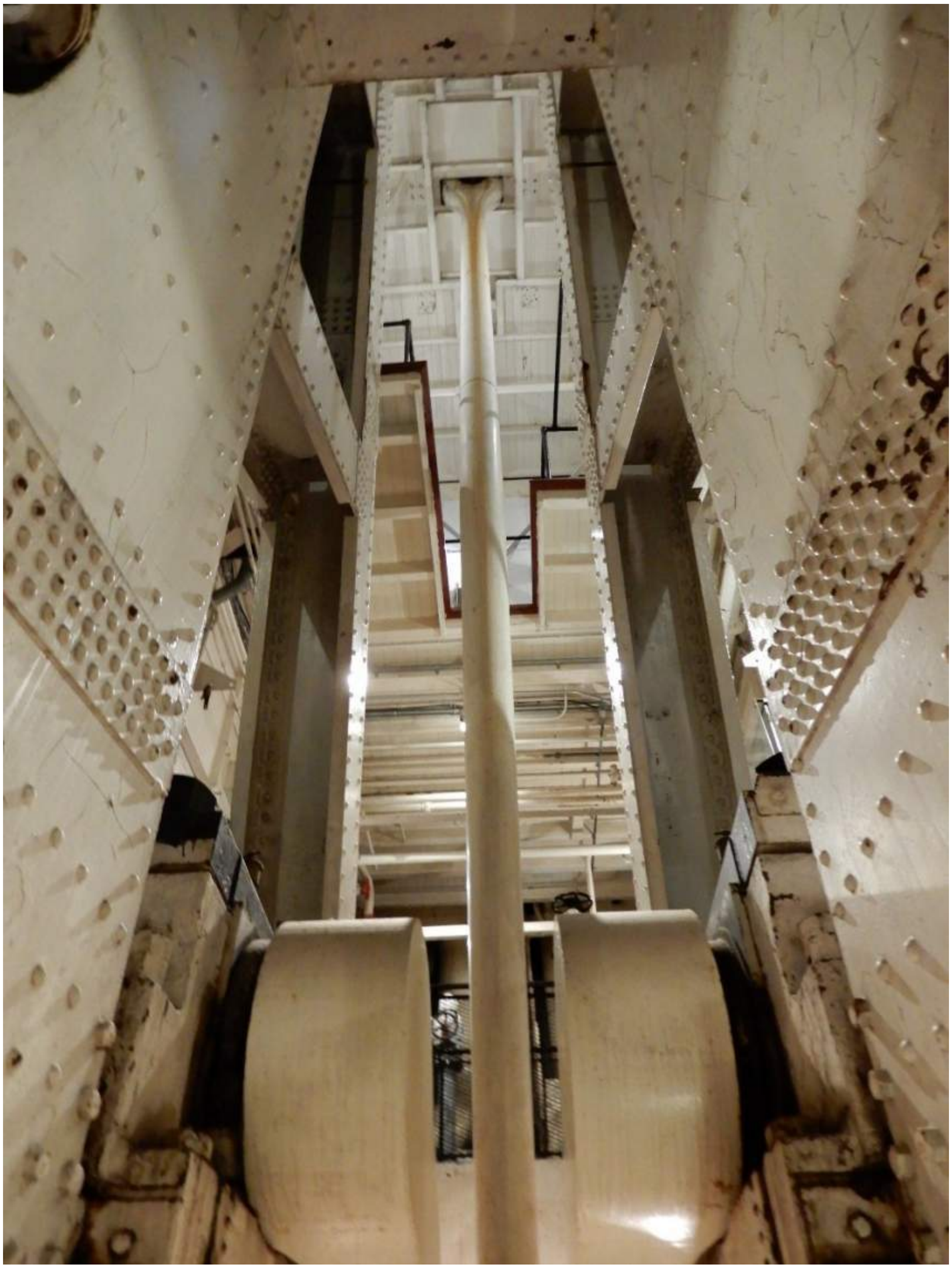
Hurricane deck, port side of bow-end pilothouse

Interior of bow end pilothouse

Interior of bow-end pilothouse

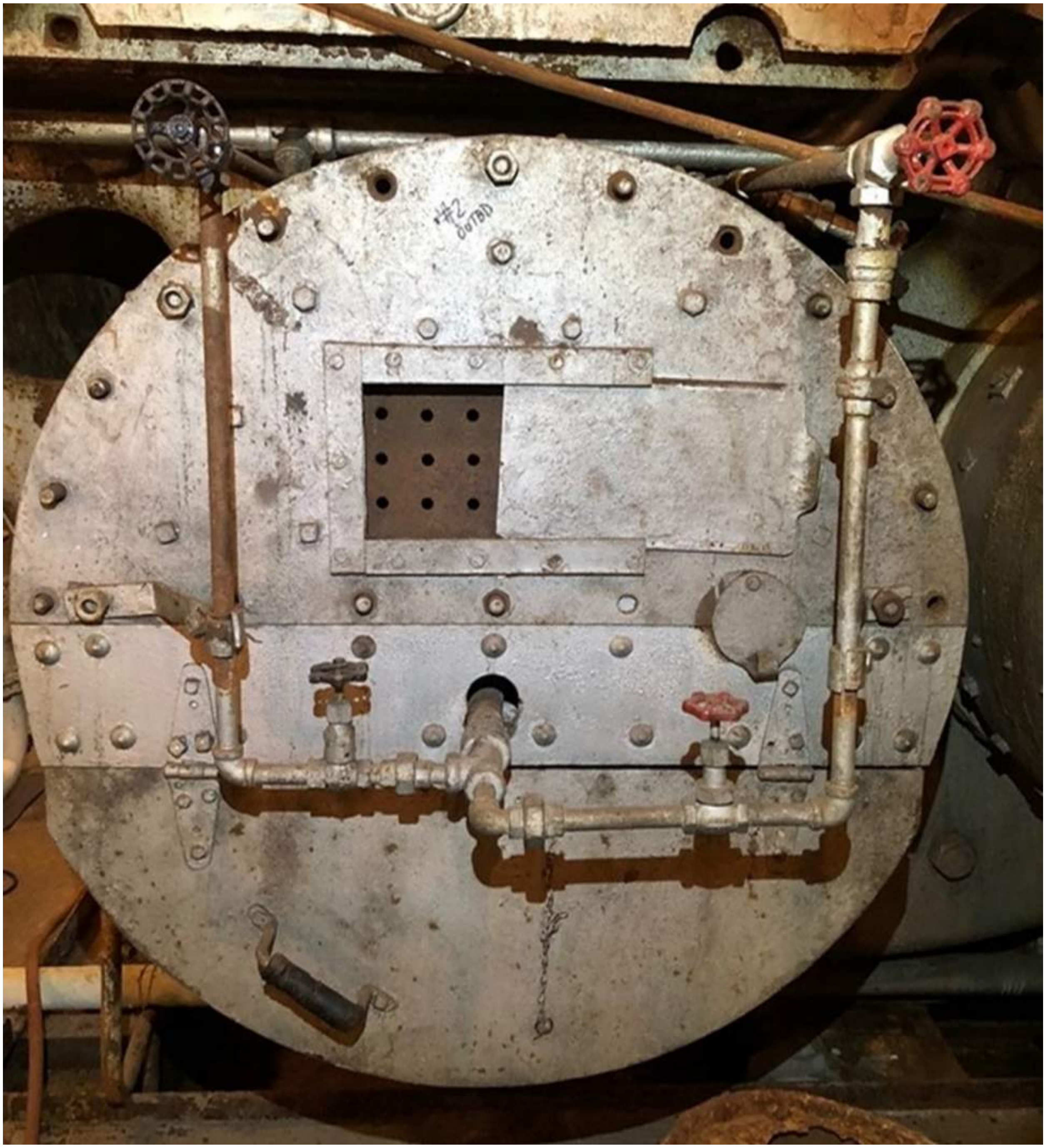
Hurricane deck, aft wall of bow-end pilothouse showing entrance to crew quarters

Typical hull interior materials, components, and arrangement



Engine room, view of walking beam engine

Steam stops at steam chimney

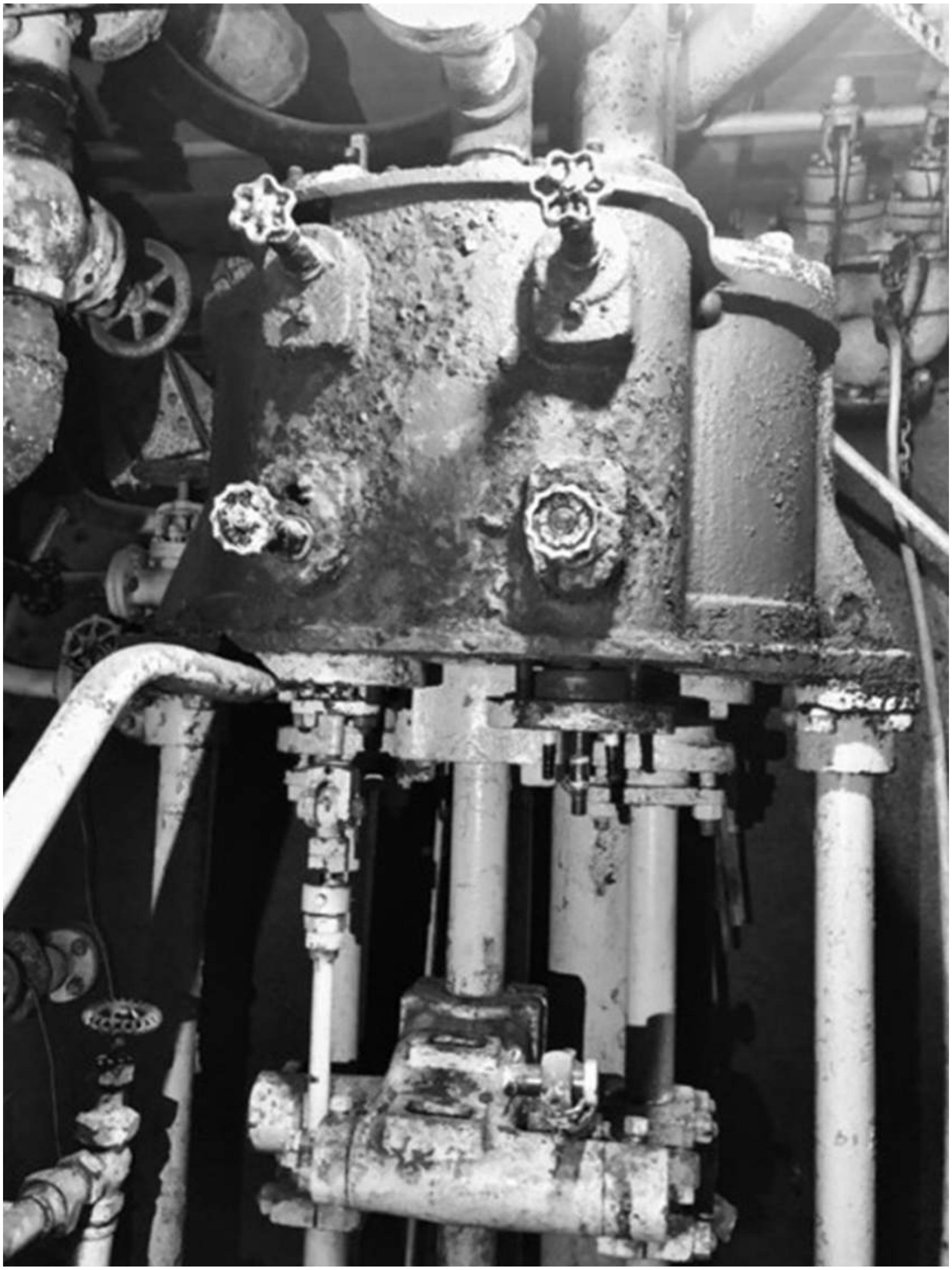


Front of Boiler No. 2

Water column

Steam condenser

Saltwater circulation pump



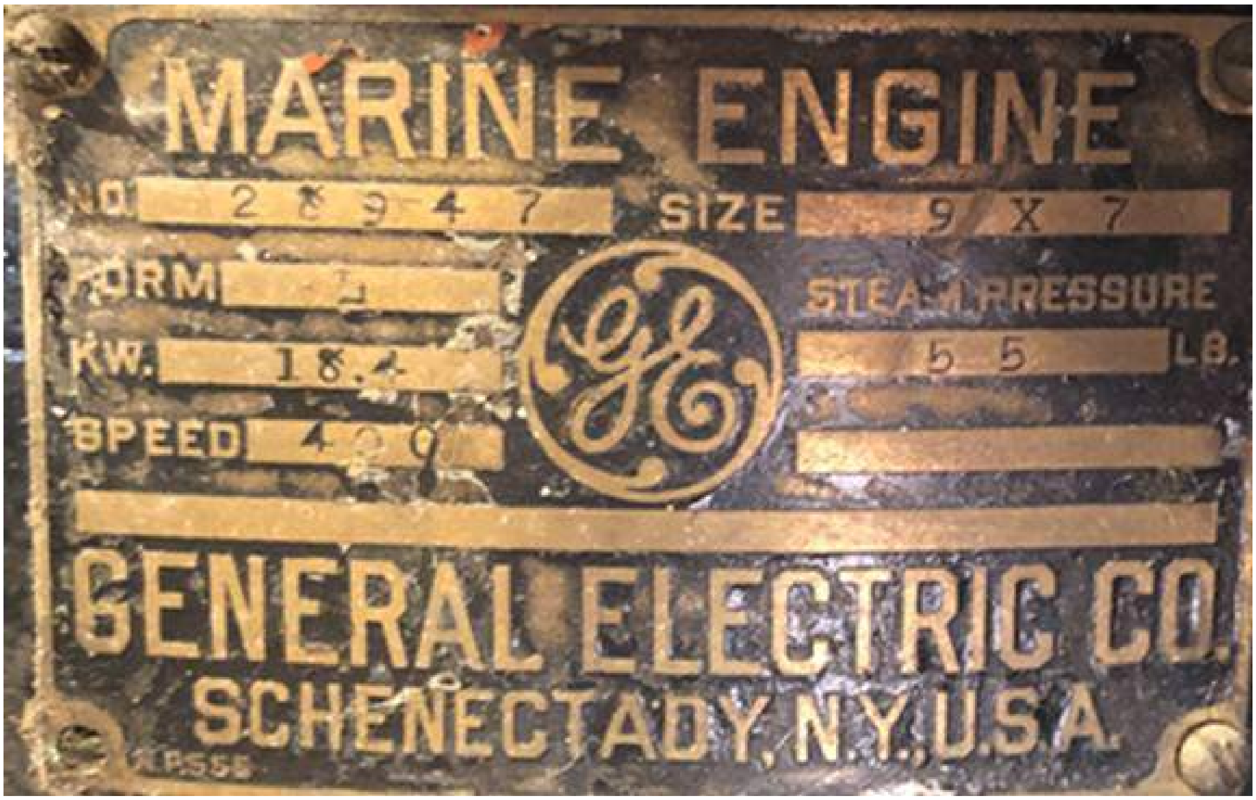
Boiler feedwater pump

Contemporary bilge pump

Contemporary PVC bilge manifold

Rudder steering chain

Dynamo No. 1 Westinghouse DC generator tag



Dynamo No. 2 GE generator tag

Shore power isolation transformers

DC electrical switchboard

Appendix D

2020 Report on the Structural Conditions of the Ferry *Eureka*

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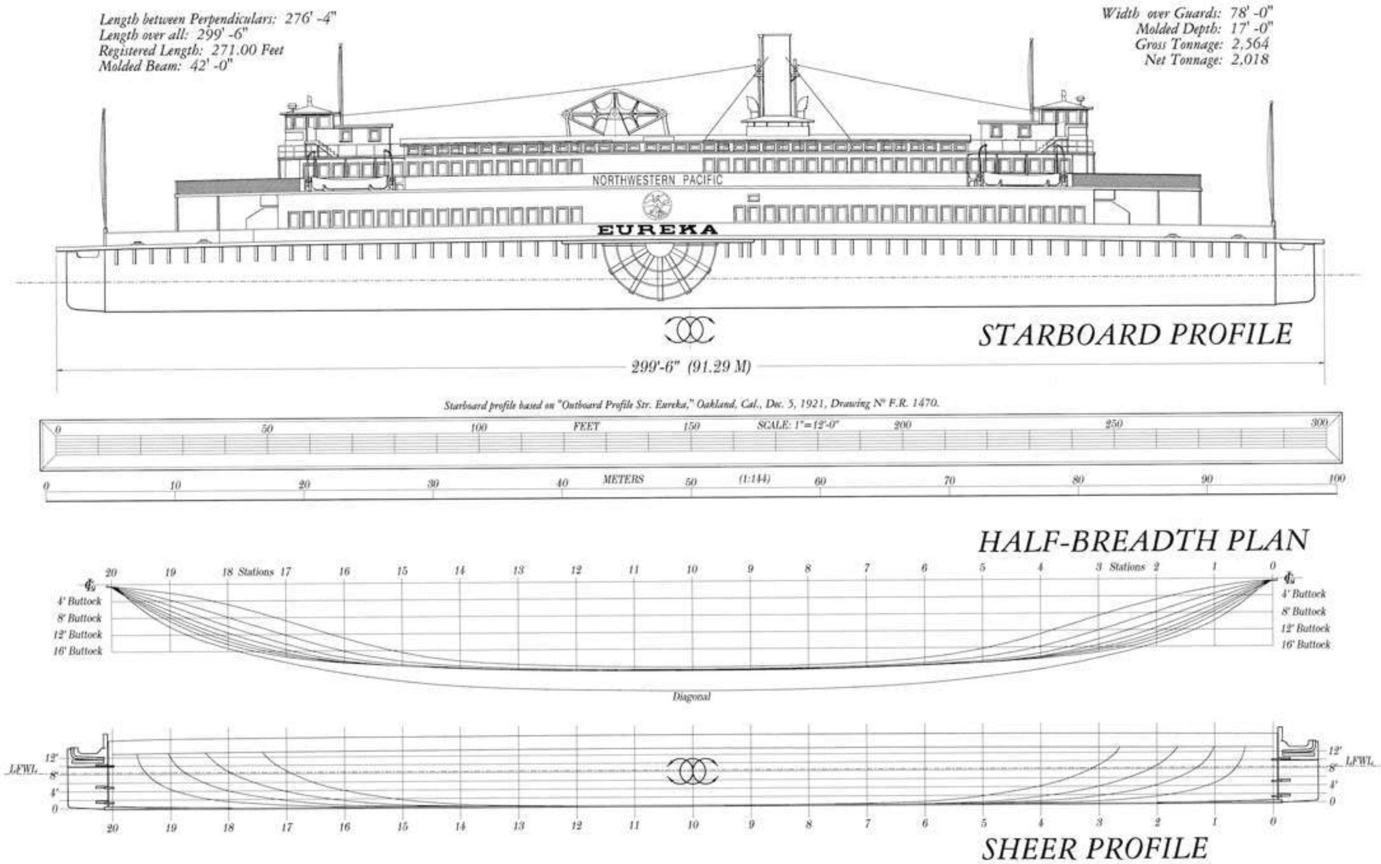
Final Task Order Report on the Structural Condition the Ferry Eureka

Title I Preliminary Engineering Report - Ferryboat Eureka Critical Systems (2020)



Drawing of Eureka by Richard K Anderson, Jr., 1996

Ferry Steamer Eureka

Final Task Order Report on the Structural Condition the Ferry Eureka Revision 2

2020

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Prepared For:
Robert Pecca & Associates/ Mott MacDonald
For the:
National park Service – San Francisco Maritime NHP For
Title 1 – Scope and Cost Validation NHL Steamer
Eureka – Critical Systems
SAFR PMIS #229380
Task Order No. 140P8619F0059

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Abstract

The historic American ship *Eureka* at 299 feet long, 80 feet wide and weighing over 3.5 million pounds is currently considered the largest floating wood structure in the world. A National Historic Landmark and a contributing feature to the San Francisco National Historic Park, the vessel is permanently moored at the historic Hyde Street Pier in San Francisco, California.

In May of 2019, the National Park Service (NPS) issued a task order under an existing contract with the objective of validating a proposed stabilization scope of work planned for the *Eureka*, further referred to in this document as the *Eureka* Stabilization Project.

The purpose of the task order, titled: Title I - Scope and Cost Validation – NHL Ferryboat Eureka Project-Critical Systems SAFR-PMIS 229380 was *"to have a qualified Architect/Engineer (A/E) team validate the proposed stabilization scope of work and update the cost estimate identified in PMIS 229380"*

Recognizing that the *Eureka* had not been dry-docked for major maintenance since 1994, along with the perceived condition of the vessel, the National Park sought to obtain an independent review to validate the scope and costs needed to structurally stabilize this historic vessel. This report and its attachments are the result of the A/E team's efforts.

The report provides a detailed analysis on the current condition of the *Eureka* as the vessel sits in the water today and as compared to the conditions observed in 1990. Recommendations are provided, which discuss possible ways forward, including conditions on the vessel that should be addressed as part of the *Eureka* Stabilization Project.

Additionally, a separate Hydrostatic Analysis of the vessel completed by Thomas Naval Architecture is provided in Section B. This analysis and the conclusions presented are based on a review of information outlined in Exhibit A Article III, Section B from the NPS *Scope and Cost Validation – NHL Ferryboat Eureka – Critical Systems* (National Park Service, 2019) as well as a comprehensive physical examination of the *Eureka* completed between November 15, 2019 and February 1, 2020.

The physical examination was performed to determine the existing condition of the vessel specific to the proposed project and to identify any conditions present that might affect the scope of the project. Specific emphasis was placed on the structural condition of the hull, deck, and superstructure including framing, internal and external planking, electrical systems, fire detection systems, fire suppression systems, and the condition of any coating systems. In essence, the examination of the vessel's structure and systems was used to evaluate the accuracy, logic and feasibility of the *Eureka* Stabilization Project proposed by the National Park Service staff.

As part of this report, recommendations are occasionally offered throughout the document; however, in each case they are further identified in Section A.10 and include ideas and suggestions with alternative means and methods for addressing project objectives.

Based on my direct observation, the *Eureka* has aged dramatically over the 30 years since her last structural survey and dry docking. The advanced decay of her timbers and corrosion of her fasteners require immediate and extensive repair for the vessel to remain in her current service.

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Acknowledgements

Robert Peccia & Associates. Mott MacDonald
Tony Guild, Maritime Technical Services LLC
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Brian Thomas, Thomas Naval Architecture
Don Birkholz, Jr. Tri-Coastal Marine
Andy Davis, Tri-Coastal Marine

Section A.1 Introduction

"*Eureka* was built in 1890, in Tiburon, California, for the San Francisco and North Pacific Railway (and named *Ukiah* to commemorate SF&NPR's recent rail extension into that California city). A freight-car ferry, *Ukiah* was SF&NPR's "tracks across the Bay, ferrying trains from Sausalito to San Francisco." (San Francisco Maritime National Historical Park, 2016)

During WWI, the vessel *Ukiah* was used to "ferry heavy loads of railroad cars across the Bay for the United States Railroad Administration. The strain was too much for the old boat, and the Northwestern Pacific obtained funds from the government to renovate the sagging hull." (Harlan & Fisher, Jr., 1951)

"Shipwrights at the Southern Pacific yard labored for two years - eventually replacing all of her structure above the waterline. This kind of reconstruction was called "jacking up the whistle and sliding a new boat underneath." Re-christened *Eureka*, the vessel was launched from the Southern Pacific yard as a passenger and automobile ferry (her present form) in 1923." (San Francisco Maritime National Historical Park, 2016)

To say the vessel played an important role on transportation on San Francisco bay would be a gross understatement. The fact is that prior to the building of the Golden Gate and Oakland Bay Bridges, the only way to move anything between San Francisco and the other surrounding cites was by ferry. *Eureka* was a part of that extensive ferry service and operated between San Francisco to Sausalito from 1922-1941.

Following the opening of the Bay Bridge on November 12, 1936 "the East and West communities of the Bay Area came together like never before. While ferries had long carried people across the Bay's often choppy waters, automobiles were the future of transportation. This meant local residents wanted a quick way to drive between the rapidly growing cities of San Francisco and Oakland. As expected, as soon as the San Francisco-Oakland Bay Bridge was built in 1936, it immediately became the favorite way to travel between San Francisco and the East Bay" (Caltrans, 2020)

The next year the opening of the Golden Gate Bridge (in 1937) all but sealed the fate for the car ferry on San Francisco bay and in 1957 the *Eureka* was removed from service.

Eureka	
Official Number:	25279
Rig:	Side-wheel Steamer
Gross Tonnage:	2,420
Net Tonnage:	1,500
Length:	299'-6"
Depth:	15'-7"
Rebuilt:	1922
Last Drydock:	1995

Table 1

The *Eureka* is now 130 years old and has not operated underway since 1959. Tri-Coastal Marine completed a historic structure report on the vessel in 1990 and noted: "*Almost as long as a football field, Eureka is one of the largest wooden structures afloat, and thus presents a major preservation and maintenance challenge. Although she was intact and in good condition when donated to the then State Historic park in 1959, neither the State nor her subsequent National Park Service caretakers have been able to keep abreast with her maintenance needs. As a result, the ensuing thirty years have left her in a serious state of disrepair.*" (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

While a major dry docking and significant repair period was completed during a 2-year yard period that started in in 1993, the funding for that work fell far short of what was needed at the time (San Francisco Maritime National Historical Park Internal Memorandum, 1993). The result is that

some of the stabilization, preservation and reconstruction work completed during that maintenance period will likely need to be re-done.

In March of 2018 an assessment of fastener corrosion and salt damage was completed in the bilge of the *Eureka* by the USDA Forest Service Forest Products Laboratory. The conclusion from that report indicated that *"the wood in the Eureka is dangerously wet." Failures may occur if mitigation techniques are not taken*" (Zelinka & Kirker, 2018)

Importantly, throughout this report references will be made to the Tri-Coastal Marine condition report *"Ferry Steamer Eureka Historic Structure Report of 1990*[i]" To assist the reader in understanding the condition of the *Eureka* today as compared to the conditions found in 1990, much of the content of the Tri-Coastal Marine report is included in the beginning of each of the relevant areas of the vessel. Additionally, the format from that report has been followed to facilitate an easy to read comparative study of the vessels condition.

Section A.2 Scope of Work

As noted in Exhibit A, Article II titled: Project Background of the NHL Eureka and Purpose of this Task Order. This report describes the current condition of the *Steamer Eureka* to assist the National Park Service in stabilizing the *Eureka* until adequate funding can be sourced that will permit a more thorough restoration of the vessel.

This proposed project would make repairs to the *Steamer Eureka* to prevent it from further deterioration and potential loss due to structural damage. This 130-year-old wooden ship is 299 feet long, 80 feet wide and weighs over 3.5 million pounds and will eventually need to be transported to a dry dock facility to complete repairs which currently include the following:

1) Outboard repairs:
   a) Apply a corrosion resistant flexible bonding to the wooden hull's copper sheathing;
   b) Replace caulking in the planking seams of the wood hull and paint wooden portion of hull with a durable marine-grade coating;
   c) Repair/replace portions of the damaged and sagging wooden fender around the ship's perimeter and paint entire rail; and
   d) Tighten the cantilevers (support brackets) that hold the large sagging overhanging decks.
2) Exterior work:
   a) Replace severely-rotted wood framework and planking on both decks;
   b) Replace and re-secure structurally-unstable and loose mooring points;
   c) Replace the second deck stairway, which is collapsing with the underlying deck;
   d) Repairs and painting of rotted exterior metal equipment and structures;
   e) Replace non-functioning guy wires intended to hold up the smokestack;
   f) Paint and preserve the underside of the car deck; and
   g) Clean debris from the exterior and paint.
3) System improvement installations:
   a) New fire detection and suppression system;
   b) New dehumidification, heating and air circulation system to lower the humidity in the hull;
   c) Bilge water pumping system that will continually remove standing water;
   d) Emergency high volume water pumping system;
   e) Replace obsolete piping and high energy electrical systems with modern, energy efficient systems; and
   f) Staging and fall protection systems on the exterior of the vessel so that cleaning and maintenance can be performed safely.

(a) Definitions

The following list of definitions are provided to assist the reader throughout this report:

Backbone: See Keel

Beam: A structural member supporting a load applied transversely to it. The transverse members of a deck framing system; the width of a vessel.ii

Breast hook: Timber knees placed horizontally between the converging forward ends of stringers to reinforce their connection to the stem.

Blemish: Anything, not necessarily a defect, marring the appearance of wood. (Department of the Navy, 1957)

Carlin: The fore and aft members of the deck framing system.

Caulking: Cotton, oakum or other fiber driven into planking seams to make them watertight.

Ceiling: An inner skin of the hull often used to add strength. In some cases, the ceiling is not structural but merely serves to line the hull for decorative purposes or for ease in cleaning.

Clamp: A heavy longitudinal member secured to frames as a support for ends of deck-beams of a poop, forecastle, or raised quarterdeck: strake immediately below and reinforcing the shelf, in the case of continuous decks, and on which the beams rest.

Covering Board: A plank used as a "washboard" or "plank sheer" along the outer edge of the deck.

Decay: The decomposition of wood substance by fungi.

1. (Advanced or typical) – the older stage of decay in which to destruction is readily recognized because the wood has become punky, soft and spongy, stringy, ringshaked, pitted or crumbly. Decisive discoloration or bleaching of the rotted wood is apparent.

2. (Incipient) – The early stages of decay that has not proceeded far enough to soften or otherwise perceptibly impair the hardness of the wood. It is usually accompanied by slight discoloration or bleaching of the wood.

Defects: Any irregularity occurring in or on wood that may lower its strength. (Department of the Navy, 1957)

Delignification: Removal of lignin from woody tissue (as by natural enzymatic or industrial chemical processes)

Diagonal Straps: Steel structural reinforcements added to the hull to provide additional rigidity to the hull girder.

Double-Sawn Frame: A transverse Frame made up of two layers of short pieces (*futtocks*) with the end joints between the futtocks staggered between layers

Dry Rot: A term loosely applied to any dry, crumbly rot but especially to that which, when in an advanced stage, permits the wood to be crushed easily to a dry powder. The term is actually a misnomer for any decay, since all fungi require over 20% moisture to grow.

Faying Surface: a term used to describe the contacting surfaces or faces of two similar or dissimilar materials placed in tight contact to form a joint.

Floor*:* The lower part of a transverse frame, extending outward from the keel toward the turn of the bilge; the lower futtocks of a double-sawn frame.

Frame: The transverse structure that establishes the form of the hull and that carries transverse loads. Frames connect to the keel or keels near the centerline and to the clamp or shelf at the sheer.

Futtock: An individual component timber of a double-sawn frame

Garboard: The strake of planking nearest the keel.

Hanging Knee: a strengthening bracket used between frames and deck beams.

Hog: Is used to describe a condition where a vessel, or part of it, like the keel, develops a convex

profile-the ends droop, and middle rises. (Davis, 1993)

Iron Sickness: Damage to the wood surrounding a ferrous metal fastener that is corroding. Rust from the fastener, which expands up to seven times its original thickness damages the wood surrounding the fastener in question. The larger the fastener, the greater the area of destruction. Iron sickness should not be confused with rot. (Slaymaker, 1992)

Keel: The bottom-most longitudinal structural member of the hull of a ship. The frames usually meet the keel perpendicularly

***Keelson**:* An inner keel usually laid over the floors and through bolted to the keel.

Moisture Content (MC) of wood: is the weight of the water in a sample divided by the weight of the dry wood material in the same sample. (Thus, a sample of which half the weight was contributed by the absorbed water and half by the wood itself would have a Moisture Content of 100%.

Preservation: The act or process of applying measures to sustain the existing form, integrity, and material of a vessel. It may include initial stabilization work, where necessary, as well as ongoing maintenance.

Plank: Longitudinal strips of wood that form the outer "skin" of a vessel. Individual planks joined end-to-end form *Strakes* of planking.

Pointer: See Breast hook.

Punk or Punky wood: rotten wood especially wood permeated by the mycelium of pore fungi. See also Rot, or Decay.

Reconstruction: (1) The act or process of creating by new construction the accurate form and detail of a particular vessel as it appeared at a specific period of time; (2) a vessel, or part thereof, that is a product of such process.

Reproduction: (1) The construction or fabrication of an <u>approximate copy of an object:</u> (2) an object that is the result of such a process.[1]

[When applied to a vessel, the term "reproduction" or "replica," denotes: (1) the act or process of recreating by new construction <u>the general form and appearance</u> of a particular vessel or type of vessel; or (2) a vessel that is the product of such a process.]

Restoration: The act or process of accurately recovering the form and details of a vessel as it appeared at a particular time by removal of later work, or by replacement of missing or substantially deteriorated earlier work.

Rot: See Decay.

Sag: The opposite of Hog. (Davis, 1993)

Sheer Strake: The top or uppermost strake of planking in a hull.

Sister: As in "sister-frame" or "sister-keelson". A member laid alongside, either in contact with and fastened to, or separated from, an original member to strengthen it, either as an original construction technique or as a repair.

Stabilization: The act or process of applying measures designed to arrest, retard, or prevent deterioration of a vessel, and to assist in its structural integrity. This may include rendering the vessel weather resistant and watertight. The essential form of the vessel shall be maintained during this process.

Strake: A run of planking at a given height from bow to stern, usually comprising a number of individual planks.

***T'ween deck**:* a deck that is located between the space's deck or bilge, and the overhead of the same compartment.

(b) Report of Survey

This report is drafted as an addendum to the Tri-Coastal report titled *"Ferry Steamer Eureka Historic Structure Report of 1990"*. Since that publication provided a comprehensive report on the condition of the vessel, it made sense to follow that documents format including the descriptions provided. We italicize each of those previously-

drafted sections to differentiate between what was observed in 1990 versus what was observed in December of 2019. Credit for the drafting of those sections goes to Mr. Don Birkholz, Jr. and Tri-Coastal Marine.

We examined the vessel in late 2019 and early 2020 in each of the same areas as discussed in the 1990 report. The following sections document the condition of the vessel today and describe what aging or deterioration has occurred since 1990.

(c) Hull

Description:

The Steamer *Eureka* is a traditional heavy-timber plank-on-frame vessel propelled by a walking-beam steam engine driving side paddle wheels. The vessel was originally constructed of Douglas Fir with double-sawn frames approximately 25" on center (O.C) and having a molded dimension that varies from 9" near the sheer line to 14" below the waterline. The vessel has overhanging sponsons that are supported by alternating hanging knees and support braces on the hull's exterior. See Photo 1.

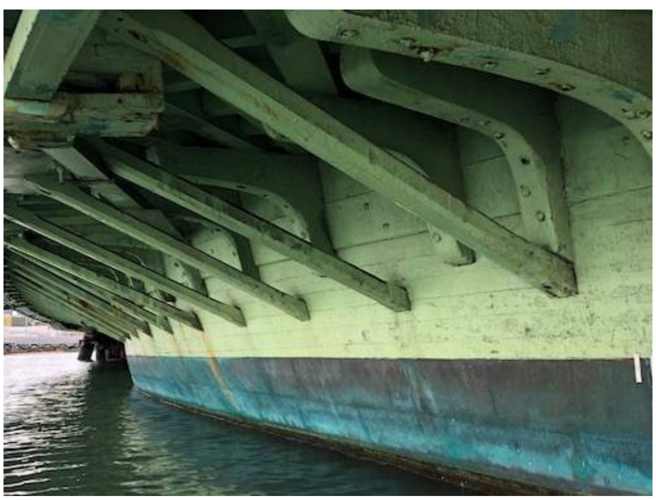

Photo 1: Hanging Knee & Sponson Braces

The upper two sheer strakes and the upper and lower clamp planks are dimensionally thicker than the rest of the hull planking and ceiling. The clamps are 4" x 16" while the sheer strakes are 5" x 16". 8-inch-deep deck beams at 35" on center (O.C.) provide support to the car deck and structure above. Structural ceiling for the hull is provided to the turn of bilge. Originally, the deck beams were constructed in one length side to side except in the way of the engine room; however, repairs over the years have included numerous deck beam sisters of both wood and steel-plate types.

The structure supporting the paddle wheels and paddle wheel box is a complicated composite that consists of a large truss built into the vessel's structure. The truss comprises the forward and aft deck beams surrounding the paddle box both of which span the width of the vessel, four king posts, bearing beams and a series of large diameter rods that make up the truss assembly. The structure provides primary support to the weight of the drive shaft and of the paddle assemblies that extend beyond the vessel's hull. See
Figure 1

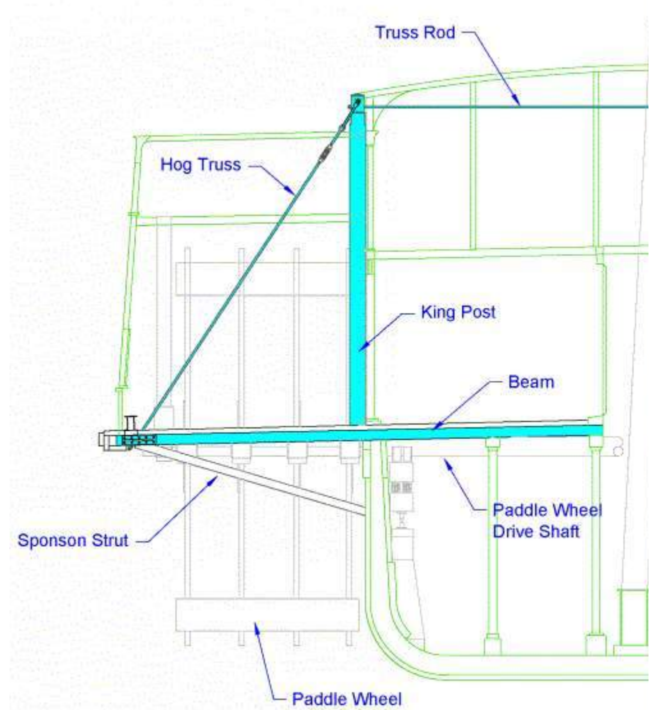

Figure 1: Paddlewheel Truss Support Details

Section A.3 Summary of Condition from 1990

Although Eureka is presently open to the public, she is nearing the point where further deferral of major preservation work will have irreversible effects. When donated to the state in the late 1950's. Her hull was in good condition, largely because of an extensive rebuild in 1953-54. The hull has deteriorated relatively slowly since that time, thanks mostly to the protective effects of the large overhanging superstructure, or "house". The house has undergone several rebuilds since Eureka became a museum ship; the relatively lightweight construction made the work straightforward, much like rebuilding a shore-side structure. The hull, on the other hand, can only be repaired while in dry dock, and with considerable effort. It is this work that the Museum now faces. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Section A.4 Current Condition

The last thirty years on the *Eureka* are rather expected in terms of how the vessel has aged. Although Park Service personnel are continually conducting maintenance on the vessel, there are limitations to what can be accomplished with the in-house resources and capabilities located at the park. Generally, the condition of the vessel suggests that even keeping up with the cosmetic appearance of the vessel is a challenge with the present allotment of resources. An example of this can be observed by examining the outboard exterior of the vessel (See Photo 2), which reveals early-to-advanced stages of decay in some locations and a considerable growth of moss on the tongue and grove exterior. Rotating the vessel at the moorings periodically would help to ensure maintenance to the outboard side is not differed to periodic drydocking of the vessel.

Photo 2: Exterior of Outboard Side of the Eureka

That said, it should be noted that the ongoing work that is being performed appears to be prioritized with meeting inasmuch as possible the *Standards for Protection* and the *Standards for Preservation* as outlined in the Secretary of the Interior's Standards for Historic Vessel Preservation Projects[1].

Most of the ongoing repairs seem to be focused on keeping the water out of the superstructure, preserving the mooring attachment points on the vessel and maintaining the vessel's coating systems. The efforts, while noteworthy, are clearly not enough to keep up with the effects of both time and the environment. As an example, during this examination there were periods where rainwater was observed leaking into the vessels structure in several locations. As expected, the area surrounding the water entry points had elevated moisture readings and in many cases above the threshold that is conducive to rot. It is important to understand that decay (rot) is somewhat slow when the temperature range is below 50º F and above 95º F and is said to stop altogether when the temperature is below 35º F or above 100º F. and importantly *"Serious decay occurs only when the moisture content of the wood is above the fiber saturation point (average 30%). Only when previously dried wood is contacted with water,*

[1] The Secretary of the Interior's Standards for Historic Vessel Preservation Projects is a document provides uniform standards for preservation projects involving historic vessels

such as provided by rain, condensation, or contact with wet ground, will the fiber saturation point be reached." (The Encyclopida of Wood, 2007). And *"Decay fungi cannot develop in wood that has a moisture content of 20 percent or less."* (Department of the Navy, 1957), which means the goal for a wood vessel is to keep the moisture content of the wood structure below the 20% threshold where possible.

Pocketing water was observed and in some cases wood structural components were found soft and punky due to the effects of wood decay. Some timbers were also displaying wood deterioration around corroding metal fasteners, which is a byproduct of the corrosion of metal fasteners in wet wood. The results indicate numerous locations where the structure has been weakened and, in some cases, compromised.

The superstructure was observed sagging in spots and there are wood defects in the form of decay and crushing damage in numerous locations throughout the vessel. In 1993 it was said of the *Eureka*:

> *"her sheer is visibly distorted; it sags down at the ends, rises up about a quarter of the way back from each end, and sags again amidships under the weight of the massive steam engine and boiler".* (Davis, 1993)

That description remains apt today. Although neither the keel nor main deck were sighted during this survey, a freeboard survey was undertaken and confirms that *Eureka* continues to sag amidships and at the ends. See Section B.

Underwater Wetted Surface:

For information purposes: The wetted surface of the *Eureka* is covered with 12,771 square feet of 15" x 48" copper sheathing strips. The strips are attached to the hull with 1-1/4" copper sheathing nails spaced approximately 4" x 4".

When installed during the 1993/94 drydocking of the vessel and after numerous discussions between park service staff, shipyard personnel, and the project Naval Architects, the copper sheathing was installed as follows:[iii]:

- The underwater hull received one (1) mist coat of F-121 vinyl red antifouling Mil-P-15931 paint.
- Immediately prior to applying the felt[2] the hull received a troweled-on ¼" coat of Henry's #504 Plastic Roof Cement.

General Observations:

The following list of conditions appear to have worsened since the vessel last drydocking and as recorded in the 1990 Tri-Coastal report. This information along with the conditions observed indicate that time is not being kind to this vessel and that comprehensive stabilization, potential rehabilitation, restoration as well as reproduction work will need to be considered and completed to maintain the long-term viability of this historic landmark. Conditions include:

- Extensive rot in the frame timbers, at the heads and at the turn of the bilges,
- Planking defects noted at sheer strake,
- Ceiling in the forward and aft peak compartments discovered with advanced decay,
- Extensive corrosion found in metal fasteners on futtock frames, hanging knees, ceiling and in planking; This is assumed due to the following facts:
    - Extensive fastener corrosion discovered on interior fasteners where the wood Moisture Content is lower than that planking under the waterline.

[2] The term felt or Irish felt is a traditional material placed between layers of planking and between the hull's planking and copper sheathing.

- Planks falling off the vessel at the last drydocking. See photo 4.

- Hogging straps are showing extreme corrosion where visible. See Photo 18 and Photo 19.
- The indication of fastener and hogging strap degradation pose grave questions about the ability of the hull structure to support its own weight.
- Copper sheathing thinning, flaking above waterline, and possible missing in some areas below the waterline. We assume that the presence of marine growth on the bottom suggests the copper sheathing is no longer intact**.** See notes on Underwater body.
- Extensive rot in structure (overhead and siding) above the male head on the passenger deck.
- Wood surrounding the heads and the nuts of metal fasteners on interior structure showing evidence of wood delignification around the fastener heads.

Photo 3: Planks that fell off boat in 1993

Photo 3 above shows the hull in drydock. The yellow arrows are pointing to a portion of the Garboard plank, which is missing. The timber under the missing plank is the keel, which is shown resting on the dry dock blocks.

- Hurricane deck dome structure sagging in spots. This condition may actuality be a combination of sagging support structure combined with vessel's smokestack guy wires pulling the structure up. See Photo 20.

Section A.5 Hull Compartments

(a) Forepeak and Afterpeak

Description: *The forepeak and afterpeak are located at the fore and aft ends of the hull respectively. The forepeak is 17'-5" in length, from the collision bulkhead at frame s60 to the stern (frame s69), and afterpeak is 17'-3" in length, from the after-collision bulkhead at frame o53 to the sternpost (frame o62). The peaks are "void spaces" (Compartments with no intended usage) created by the collision bulkheads. They are presently empty, with exception of the stern mooring chain in the afterpeak. There is a platform in each peak. Access is through small hatches in the main deck. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)*

Condition in 1990: *Other than the decayed hull structure noted earlier, the peaks are fair in condition. The moisture level in these small compartments has dropped since plywood sheathing was installed on the leaking deck above. The hatches in the collision bulkheads have been removed to increase ventilation. Further measures, including forced-air and repair of main deck, will need to prevent further decay. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)*

After Peak (Oakland Side) Current Condition:

Access to the After Peak on the Oakland End of the vessel was made through the original access hatch in the vessel's aft collision bulkhead. The access hatch has been long since removed and in the last two years a metal screen has been installed to prevent rodents from moving between the compartments while still allowing cross ventilation. The compartment was fitted with a temporary t'ween deck walking platform

surrounding the periphery of the port and starboard side shell.

Temperature and Humidity After Peak[3]	
Temperature	55.6°F
Relative Humidity	80 %

Table 2

This temporary deck provided good access to the upper and lower clamp and of the vessel from the collision bulkhead to the bow. The first strake of ceiling (inside planking) below the upper and lower clamps on the starboard side had previously been removed allowing access to the underlying structure. Specifically, the missing ceiling strake allowed access to the frame heads for frames o54 through o61. The forward and aft portions of the remaining ceiling plank ends showed signs of excessive decay indicating one possible reason the section of ceiling had been removed. Frame heads on all visible frames (o54 through o61) as illustrated in Figure 2 were showing signs of advanced decay. M.C. was recorded at or above 26% although the wood was not visibly wet[4]. When probed, the wood was soft and, in some cases, caved in under the lightest pressure. Likewise, when sounded with a hammer the wood easily deformed. Several fasteners were able to be examined in way of the removed ceiling and were found with moderate to severe corrosion. Several bolts heads were sounded, and some held solid while others displayed severe loss of strength. Two (2) were removed due to extensive corrosion and for further examination.

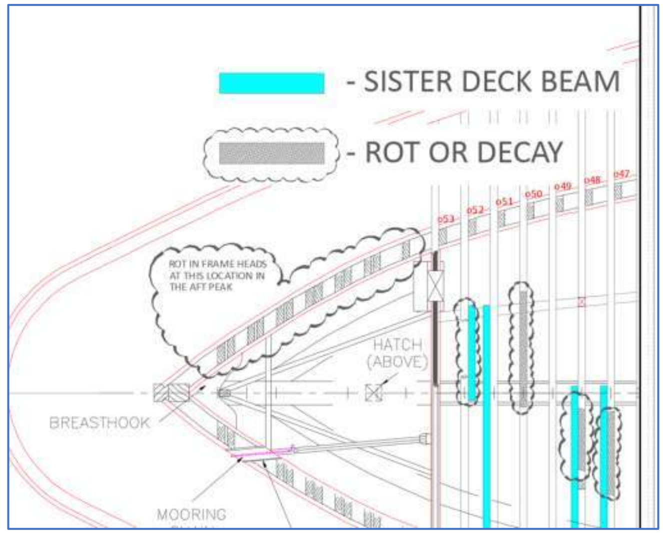

Figure 2: Illustration of Rot in Aft Peak Frame Heads

Temperature and humidity readings were taken and are recorded in Table 2.

The upper and lower clamp (Figure 3) was discovered with indications of delignification of the wood surrounding the inside visible portions of the outside hanging knee fasteners and included advanced rot in some areas. Approximately 120 linear feet of the upper and lower clamps in this compartment will need to be replaced.

The stem post above the stem knee was found with excessive rot and is soft when probed above the keelsons. This was also noted in November 1993 during the extensive repairs to the deck and fan frames.

[3] Where reference to temperature and humidity are made. Readings were taken from a Bionaire battery operated temperature and humidity gauge.

[4] Moisture readings were obtained using a Ligno Scanner STD with a setting of "46" @ a depth of 0.75" and a TRIMEX Skipper plus.

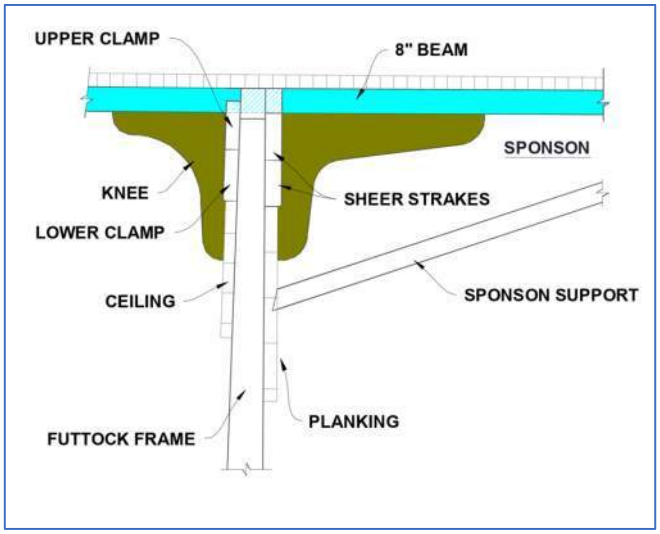

Figure 3: Illustration of Sponson Section

The pointer located behind the stem and over the sheer clamp was sounded and produces a hollow sound when hammer tested noting possible decay under the surface. This is a structural member and drill gauging should be considered to confirm soundness.

The deck structure in this compartment remains watertight (it is not visibly leaking rainwater or water washdown), although the structural integrity where the deck beams tie into the frame heads is virtually nonexistent due to advanced and extensive decay present at the frame heads. Essentially, the deck is resting on the hull's structure in this location and the fasteners securing the deck to the hull are unable to perform their function due to the advanced rot in the frame heads.

The collision bulkhead comprises carvel planking and diagonal tongue and groove (T&G) with Irish felt placed between the faying surfaces to improve the watertight integrity of the bulkhead. While the bulkhead appeared in sound condition, there is evidence of bleeding fasteners or running rust lines at the attachment point to the side shell and on a good portion of the T&G. The bulkhead attaches to the side shell on a bulkhead frame that rests on the ceiling above the turn of the bilge and on the top of a frame below the ceiling.

Some of the wood diagonals are loose and in some cases were easily pried away from the opposite carvel planks underneath due to decay. The underlying felt was found deteriorated and in overall poor condition as would be expected for its age. The connection points to the side shell appeared sound; however, due to the fastener conditions found in other areas of the hull the structural condition of these fasteners is questionable at best.

The bilges were found moist with very little standing water. There was no bilge alarm switch visible in this space, although wiring was present and assumed to be a part of a previous alarm system. AC electrical wiring was a hazard to anyone entering the space due to extreme corrosion of the metal switch housing and electrical conduit and should be repaired as soon as possible.

Futtock frame fasteners we're sounded with a crescent wrench and found weak. (when pressure was put on one end of the fastener the faster turned slightly while the other end of the fastener remained stationary; an indication of low torsional strength).

Forward Peak (San Francisco End) Current Condition:

Access to the forward peak compartment is similar in all respects with the access of the after peak; however, there was no anti-rodent screen present in the collision bulkhead access hatch and the space is fitted with an additional access hatch located under the stairs leading up to the passenger deck from the car deck.

This compartment was also fitted with a temporary t'ween deck platform surrounding the periphery of the port and starboard side shell.

Temperature and Humidity Forward Peak	
Temperature	54.5°F
Relative Humidity	88%

Table 3

Similar to the afterpeak, this t'ween platform provided suitable access to the upper and lower clamp from the collision bulkhead to the bow.

However, unlike the afterpeak, the ceiling (inside planking) was found intact. While examining this space rainwater was observed leaking into the compartment. The temperature and relative humidity were taken and are recorded in Table 3.

A small section of ceiling had previously been removed on the inboard (starboard) side of the vessel, which revealed some defects in the underlying frame and ceiling. (See Photo 4). To the lower right of the opening, a fastener was sounded and found loose. The fastener serves as one of the exterior hanging knee fastenings. With minimal turning effort, the fastener failed by shearing in two. See Photo 4, Photo 5, and Photo 6 for reference.

Upon examination of the removed fastener, it was observed that the bolt was necked down to 0.38" from its original diameter of OOA 0.75". This fastener was submitted to Anamet Inc. who provide materials engineering analysis and laboratory testing services, which includes materials failure analysis, mechanical and metallurgical testing, and chemical analysis. See Section A.9 for additional information on the vessel's fasteners including details from the Anamet report.

Photo 4: Fwd Peak Ceiling

Photo 5: Exterior Knee Fasteners (inside view)

Photo 6: Hanging knee bleeding fasteners

The upper and lower clamp timbers (Figure 3) surrounding the exterior hanging knee fasteners were sounded and revealed solid to soft wood. This indicates defects under the surface of some portions of the upper and lower clamps. Defects were confirmed in some areas with probing and when the hammer used to sound the clamp timbers some areas caved in indicating a serious loss of strength in some of the timbers. While the cause was not identified, the condition is consistent with rot, iron sickness or a result of, and a byproduct of corrosion to the metal fasteners in the area surrounding the fastener in question.

The apron above the stem knee and under the breast hook was sounded and probed and no defects were noted.

The overhead, which serves as the deck above was observed actively leaking rainwater during the examination. Also, based on the conditions discovered in the upper and lower clamps it is highly probable that the frame heads in this compartment are also compromised similarly to the frames in the afterpeak. This condition should be researched further with a destructive examination prior to the proposed stabilization project.

(b) Hold #2

Description: *Hold #2 is 18'-4" in length from the forward collision bulkhead at frame s60 to bulkhead at frame s51. The partial t'ween deck here is empty, except for two pallets of chain for the emergency bow anchor. Access is through a hatch beneath the forward passenger deck stairwell. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)*

Condition: *This compartment is in good condition, except for minor occurrences of local decay in the lower hull structure. The worst of these is a rotten support block under the hold pillar at frame s60. This should be replaced. The anchor chain stowed here is rusting and should be coated to prevent further deterioration. Cleaning of bilges and improving ventilation are recommended as preservation measures. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)*

Condition in Dec 2019:

This compartment was well ventilated and the temperature and humidity in this space are recorded in Table 4. As noted in 1990, decay remains a persistent problem in this space and was observed in the visible portions of the frame sections below the ceiling. Considering the 30 years that has passed since the 1990 report, it is assumed that this condition has worsened albeit to what degree is unclear. Several square head fasteners on the clamp timbers were sounded and found tight with sound wood surrounding the fastener heads in varying condition. The wood surrounding the clamp in way of the steering chain bearing box was in poor condition with rust stains emanating from the fasteners in this area. The common term for this condition is "bleeding fastener", a term used to describe an iron or steel fastener that is rusting in wet wood.

Below the t'ween deck the ceiling timbers were found in good condition; however, all of the fasteners were bleeding and had salt formations surrounding the heads. None of the ceiling fasteners were removed for examination.

In the compartment's bilges, floor and futtock fasteners are in questionable condition especially those in the wettest regions of the bilges. Several fasteners were sounded and although they appeared tight, when you consider the condition of fasteners examined in other areas of the vessel (in similar locations) it is highly likely they are in varying degrees of advanced corrosion. Therefore, it is recommended that several should be removed to determine the extent and severity of any corrosion present. See Section A.9 for a more detailed discussion on the vessel's fastenings and fasteners.

Temperature and Humidity Hold #2	
Temperature	52.2°F
Relative Humidity	88.8%

Table 4

Moisture readings of the timbers revealed a M.C. between 12 and 26% with the higher readings

found in the vicinity of the compartment's forward bulkhead in the overhead.

The bilges were found with some standing water with a mud or scum line that indicates that at some point in the past it has been much higher.

The compartment's aft bulkhead at frame 51 was found with bleeding fasteners and where the bulkhead meets the keel was found soft and punky. For descriptive purposes the frames are comprised on 4" horizontal carvel planks with a diagonal T&G planking on the opposite side. Fasteners on the diagonals were observed bleeding. The frames cleating the bulkhead to the ceiling and lower frame and floors was found in relatively good condition and appeared watertight, (see Photo 21)

(c) Hold #3

Description: *Hold #3 is 48'-0" in length, from the steel engine room bulkhead at frame s28 to the wood bulkhead at frame s51. The partial t'ween deck in this compartment is used as a storage area and presently contains a considerable amount of supplies and equipment. The steam steering engine for the bow rudder is located on the t'ween deck, to port. The bilge is empty, except for a steel potable water tank. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)*

Condition: *There are no major deficiencies in Hold #3. Scattered minor areas of rot are seen in the lower hold, though none are significant. Main deck beams and deck planking are rotten at the forward end of the hold, near the centerline. The decay here is old and is not a priority. The potable water tank in the hold is rusting and should be preserved, both inside and out. General recommendations for preservation of the hull apply to this compartment. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)*

Condition in Dec 2019:

We found the condition of this space to be much the same as was reported from 1990, albeit 29-years older. Supplies and equipment from the upper t'ween deck area have been removed and the compartment remains for the most part empty. The interior coating on the side shell was found in suitable condition with no real visible defects present to the underlying timbers. Cedar shims were observed in some of the seams of the ceiling and when sounded the ceiling fasteners appeared sound. None were removed for examination. The upper and lower sheer clamp were sounded with positive results suggesting the problems discovered in the forward and after peaks may be limited to those spaces. The areas surrounding the exterior hanging knee fasteners were not showing signs of delignification of the wood or corrosion as they are in the forward and after peak compartments.

The compartment was found well-lit and well ventilated. There were no signs of rainwater or deck wash entry.

The deck beams in this compartment were found in relatively good condition on the surface with one area of concern. This area was directly forward of the access hatch on the centerline of the vessel where some water intrusion is present.

The deck beams in this space provide the mounting structure for the vessel's forward steering engine. While found in relatively good condition and absent any rot or decay, gaps were observed between the steering engine's steel bracket and the attachment beams. Since this extremely heavy equipment is suspended from the deck beams, it is entirely fastener dependent. Therefore, due to the age of the mounting fasteners and corrosion discovered in other fasteners of similar size, this equipment should be shored up and the fasteners removed and examined for continued suitability.

Photo 7: Frame Heel Decay

Below the t'ween deck the bilges were found typical for this vessel. Standing water was noted in the bilges and while the level is well under the top of the floor timbers, there are also indications in this space that the water level has been or is periodically above the floor timbers. White crystals were observed on almost all of the visible fasteners including the futtocks, keel, side keelsons, bilge stringers and ceiling.

Corrosion was observed on the lower portion of aft watertight steel bulkhead at frame 28 were the steel rests against the wood frame. The rust appears to be manageable at this time and does not pose a threat to the vessel's watertight integrity or damaged stability; however, the areas in question should be de-scaled and treated. *Since this vessel would be unstable should the engine room flood, the steel bulkhead that surrounds the engine room must be treated as critical to the safety the vessel even when one considers the vessel is normally permanently moored. [Emphasis Added].* See Section C. for a detailed analysis on the damage stability of this vessel while statically moored.

We found rot in numerous frames at the turn of the bilge and between the faying parts of the double-sawn frames including s30, s34, s37, s38, s39, s40, s42, s44, s45 to name just a few. Photo 7 provides a good illustration of this condition.

In addition to the rot throughout the frames, there were also signs of bleeding fasteners and iron sickness in the double-sawn frame futtock fastenings.

Diagonal strapping (Hogging Straps) where visible, matchup with what is typical throughout this vessel. The straps are exhibiting signs of extreme corrosion; they are extremely rusted, flaking and in some cases no longer continuous. Originally 0.75" thick, in some areas they are rusted into two. Engineering should be considered to evaluate what, if any, impact this condition has on the structure while the vessel is in a permanently moored condition. See left side of Photo 7.

(d) Engine Room

Description: *The engine room is located in the midsection of the vessel. It is the largest compartment in the hull, measuring 95'-8" in length, from the steel bulkhead at frame s28 to the steel bulkhead at frame o18. This compartment houses the walking-beam engine and the four fire tube boilers. Most of the steam auxiliary equipment is also located here, along with the vessel's two operational bilge pumps and single sea-suction valve. Access to the engine room is through the control room, a small platform just below the main deck level at the aft end of the engine room casing. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)*

Condition: *The engine room is largely intact, with most of the original equipment still in place (These items are covered in sections "Machinery" and "Piping Systems"). Aside from deficiencies previously noted in the hull structure, this compartment is in generally good condition. The access ladders and operating platforms are in good condition. Much of the steel structure is rusting due to the high level of humidity here. Of particular concerns is the engine bed, which is severely wasted throughout. The bilges below the operating platforms are covered with fuel oil dating from the period of operation. This does not*

appear to be causing harm to the structure but could present a pollution problem when pumping the bilges. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Condition in Dec 2019:

The condition of the machinery space was again found in relatively good condition although as a disclaimer, none of the machinery was examined as part of this inspection. Therefore, there will be no mention of machinery condition in this report.

Permanent staging has been installed to provide access to the upper portions of the compartment on both of the outboard sides. This staging allowed examination of the frame heads where visible, the upper and lower clamps, the outer ends of deck beams, and the compartment's hanging knees. All of which were found in good condition except as noted below. At some point in the past the hull and overhead in this compartment were painted white and remains in good condition. The deck beams in the overhead appear sound and the upper and lower clamps also appear sound with no visible signs of deterioration. Some rust was observed running from several of the hanging knees indicating ongoing corrosion of the fasteners securing those structural elements to the vessel. Additionally, steel plates were observed on several of the hanging knees. These steel plates were installed during the 1993/94 drydocking after several of the knees were discovered with advanced rot. The steel plates were designed to provide additional support for the hull in this area by effectively sandwiching the knee and then adding additional through-bolted fasteners to connect the modification to the hull. This repair seems to meet the criteria of stabilization and should be identified for restoration due to the additional 29 years of aging.

The ceiling throughout this compartment has cedar shims added to stiffen the structure. All of the cedar shims appear in sound condition.

The paddle wheel outer drive shaft support structure was displaying signs of fastener corrosion. Some of the fasteners attaching the bearing support to the ceiling were bleeding and some of the wood surrounding the structure was soft.

Both of the engine room steel watertight bulkheads were examined and overall found in acceptable condition except as previously noted. Some of the steel where it contacts wood was showing signs of corrosion and there were indications that wood structure used to attach the steel bulkhead was no longer fitting tightly against the hull; however, the wood was sound and, in some areas, had been sealed with a pliable sealing compound. It again should be noted that the watertight integrity of the steel bulkheads would be critical to the survival of the vessel in the event of flooding while at the dock.

The main engine foundation or engine bed as it is described above remains in poor condition. The wood structure under the engine bed, which consisted of the keel, floors and side keelsons were not inspected through their entire length due to machinery interferences. The bilges were observed dry for the most part although as expected for a vessel of this age there was some standing water in the lowest portions of the bilge.

The lower frames and floor timbers could not be examined for the entire length of the compartment due to the installed decking.

Similar to the conditions found in other areas of this hull the heads of visible fasteners were observed with a buildup of white crystals on the surface immediately surrounding the faster head.

(e) Hold #5 Junior's Hold

Description: *Hold #5 is aft the engine room. It is 48' in length. From the steel engine room bulkhead at frame o18 to the wood bulkhead at frame o41. This compartment has a full t'ween deck which is presently serving as a storage area and crew's locker room. There are two large steel tanks one on the port side for a fuel oil. And one to starboard for boiler feedwater. The steam steering engine for the stern rudder is located on the starboard side. A*

wastewater holding tank and waste processor for the operational restrooms on the passenger deck has been installed on the port side. *The area below the t'ween deck is empty, except for the tanks which extend below the t'ween deck level.* (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Condition: *The hull above the t'ween deck level is in good condition. Below the t'ween deck several areas of local rot were seen in floor timbers, frames, and keelsons. The condition of fastenings and hogging straps is particularly poor in this hold. Probably due to periods of high bilge water levels.* (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

The t'ween deck structure is moderately deteriorated on the underside but remains generally sound, though they show corrosion on the lower surfaces. The fuel tank contains approximately 4,000 gallons of fuel oil; the water tank is full of freshwater. The steam steering engine and chain linkages are intact, though inoperable. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Condition in Dec 2019: The hull above the t'ween deck was found in fair condition. This space remains in use by Park staff as a locker room and was found neat and presentable. The upper and lower clamps in this space were in better condition than this same area in the extreme ends of this vessel. This is likely due to less water leaking into the space from the deck above, which is enclosed by the car deck structure. The deck beams were found in good condition.

Similar to the number 3 hold, the deck beams also provide the support structure for the vessel's steering engine. In this case the aft steering engine. Some of the beams supporting this equipment were observed with what appeared to be fire damage. As with the forward steering engine, gaps were observed between the steering engine's steel bracket and the attachment beams, indicating that the engine is pulling away from the supporting beams. Again, considering the hanging weight of this extremely heavy equipment and the age of the fasteners securing it to the deck beams, this equipment should be shored up and the fasteners removed and examined for continued service.

The forward bulkhead in Junior's hold comprises diagonal tongue and grove (T&G) planking over carvel planking and the bulkhead is attached to the side shell similarly to the collision bulkheads. Some of the wood diagonals are loose and, in some cases, they were easily pried away from the underlying carvel bulkhead planking. The underlying felt was found deteriorated and in overall poor condition as would be expected for its age. The connection points to the side shell were found in acceptable condition; however, fasteners were not removed for examination.

(f) Hold #6

Description: *Hold #6 is 24'8" in length from the bulkhead at frame o41 to the after-collision bulkhead at frame o53. There is a partial t'ween deck here, which is empty except for the chain for the emergency steam anchor. Access is the through a hatch in the main deck just aft of the house. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)*

Condition: *The hull is in good condition in Hold #6, but the main deck above is severely decayed. Six deck beams and much of the deck planking below the passenger deck stairwell are rotten. The decay appears to date from a previous period of wetting and has not progressed significantly repairs to this area will eventually be required.*

A general cleaning of the hold is needed to remove bilge debris and the loose lumber that is scattered about the hold. The thru-hull fitting located in the starboard bilge, at frame o45, should be inspected at the next drydocking.

Ventilation is poor in this hold and can be improved by installing fans in the existing natural-draft vents that are mounted in the stairwell above. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

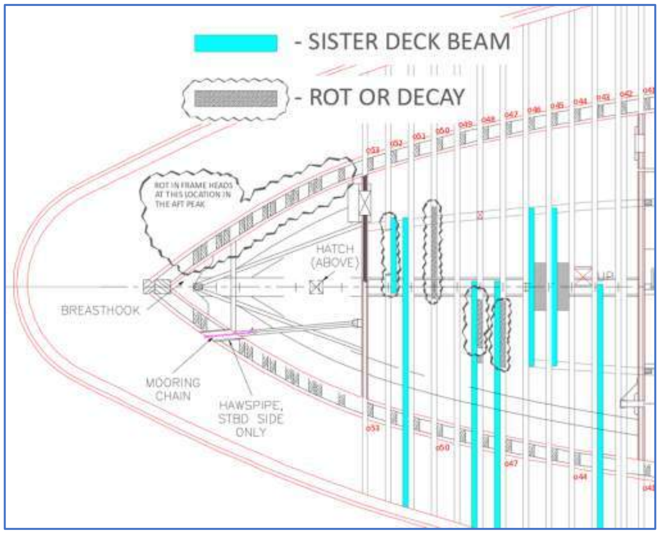

Figure 4: Location of Decay on Beams in Hold #6

Condition in Dec 2019: The hull above the t'ween deck was found in fair condition. The temperature and humidity of the space are as indicated in Table 5. The decay noted in the deck beams in 1990 remains or has worsened. The deck beam above the collision bulkhead for some length is completely missing due to advanced rot. Other beams are experiencing varying degrees of decay and are soft when sounded with the face of a hammer in and beyond visible decay. In one case the beam was probed, and a stream of water was released from the timber.

At the time of the inspection, the t'ween deck was wet due to rain draining into the compartment from the main deck. This area was found directly under the passenger deck stairwell, which is further described in section covering the Sponson Deck Fore and Aft. This area and is showing signs of sagging due to a lack of proper support from the deck beams. Some of the deck beams have been shored up using a variety of methods; from temporary shoring, to the installation of sisters placed adjacent to the original beams. Figure 4 is an illustration of the conditions found.

Temperature and Humidity Hold #6	
Temperature	54.5°F
Relative Humidity	88%

Table 5

The bilge area under the t'ween deck was found relatively dry although there was some moisture and debris in the lower portions of the bilge. As indicated in the 1990 condition report, there are some signs of decay and wood defects due to the byproducts of corrosion surrounding the fastener heads.

Almost all of the visible fastening ends in the space were observed with a buildup of white crystals substance on and around them. The wood surrounding these areas in some cases was punky and soft indicating a loss in the strength of the wood fibers or weakening of the wood adjacent to the fastener. Additionally, the sea chest on the Port side of the compartment was also found with soft wood surrounding the thru hull valve. See Photo 9. Note that this thru hull fitting has been blanked on the exterior hull.

Photo 8: 7/8" Diameter Corroded Bolt

Photo 9: Wood Defects #6 Hold Sea valve

Several double-sawn frame futtock-bolts were sounded with a crescent wrench and found to be in a weakened state. One end of the fastener turned while the opposite end remained stationary. In one case, with very little force the fastener sheared in half and was extracted revealing extensive corrosion of the fastener. The fasteners in question were originally a 7/8" diameter carriage bolts with a washer and square nut. Both fasteners failed within 3" of the nut side of the fastener.

Importantly, one can conclude that since the fasteners in this area of the vessel are of the same age as those in other areas that show advanced corrosion, they are likely to have comparable amounts of corrosion. This includes plank fasteners under the waterline as well as other structural fasteners such as ceiling planking.

(g) Main Deck

Description: *The main deck was designed to carry automobiles and was originally open from end to end, except for the engine room casing, and the paddle boxes. The main deck is longitudinally planked with 3-3/4"x3-3/4" decking laid on 6"x8" deck beams. The entire deck is covered with tongue and groove cedar sheathing which served to reduce wear from automobile traffic.*

The sponson deck, the portion of the main deck which extends outboard of the hull, is supported by the main deck beams and, at the fore and aft ends, by a series of radiating beams or "fan timbers". The outboard portions of the deck beams are supported by hanging knees and 6"x6" diagonal braces, in alternating sequence. A "rub-rail", comprised of several heavy timbers measuring 23"x30"x45', along the outboard edge of each paddle box. These support the superstructure in way of the paddle wheels.

A wire mesh partition, dating from the historic period, runs along the centerline of the main deck inside the house and separates the deck into port and starboard side. The starboard side of the main deck is presently open to the public. Antique automobiles, a horse-drawn wagon, and drays have been placed here for interpretive purposes. The port side of the main deck within the house is used as a work and storage space for the Park's maintenance crew. A portion of the deck aft of the port paddle box has been enclosed with bulkheads to form a conference and film room for Park staff. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Condition: *The main deck is in good condition inside the house, but in generally poor condition where exposed to the weather, fore and aft. The entire deck structure over the forepeak and aft-peak is severely rotten and leaking. Another area of sever rot is seen in deck beams and planking over Hold #6, as mentioned previously. These areas require major structural repair.*

Less severe occurrences of rot are seen in deck beams and planking, particularly above the engine room. Most of these areas can be treated with wood preservative, through repairs may eventually be necessary. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Sponson Deck: *The rub-rail is rotten for almost the full length, port and starboard, and most of the deck beams are rotten at the outer ends. Pigeons are nesting in the rub-rail, and the accumulation of their droppings is contributing to this rot. The beams will have to be sistered and the wasted rub-rail replaced. Almost all of the diagonal sponson braces and hanging knees, though weathered, are sound. Most of the deck planking and inboard sections of the deck are sound.*

Both of the spring beams, the large timbers outboard of the paddle wheels, are severely wasted and must be replaced.

The deck beams and planking overhanging the fore and aft ends are extensively rotten and will have to be renewed, along with rebuilding of the forepeak and aft peak. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Paddle Boxes: *Both paddle wheels are weathered and the frames and fittings severely corroded. The steel paddle box bulkheads are wasted through in some areas. Both paddle wheels and paddle boxes*

will require preservation, including sandblasting or scaling, and painting.

The riveted steel support beams at the ends of the shaft, port and starboard, are severely wasted. The beam on the starboard side is in the worst condition, with wastage estimated at seventy percent. The port beam is showing approximately thirty percent wastage. Both beams should be repaired, sandblasted, and painted.

The wooden king post appear to be in good condition. The interior sheathing of the paddle boxes is weathered, but otherwise sound. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Condition in Dec 2019:

Main Deck:

The condition of the main deck, in spite of the major overhaul completed in 1993 and 1994, remains somewhat similar in all respects to that described in the 1990 report with some subtle differences. Specifically, that portion of the main deck inside the house was found in relatively good condition due to the protection afforded by the house. On the other hand, where moisture has entered the structure especially on the outboard side of the vessel from the men's head the damaging effects are noticeable and have appreciably worsened.

Sponson Deck:

As noted earlier, both the forward and aft radiating fan timbers supporting the sponson decks were found to be in good condition; however, the outer edges of the deck at the bulwarks was found to have advanced rot. Importantly, during the 1994 rebuilding of the fan ends the timbers supplied to the government for this work were reported to have been treated with pentachlorophenol. The wood was government supplied surplus, approved by the National Park Service Western Region Safety Officer.

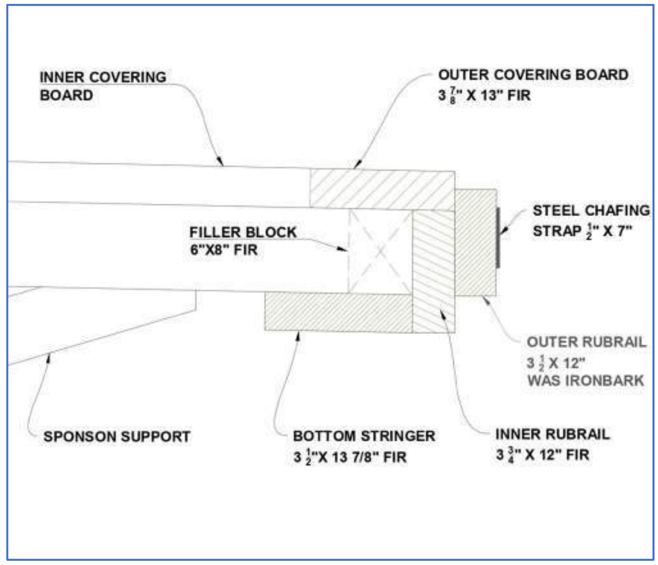

Figure 5: Details of Rub Rail

Any work performed on the materials in this area of the hull will require added safety precautions. Additionally, any waste generated from sawing operations will need to follow strict California State and Federal hazardous waste removal and transportation requirements.[iv]

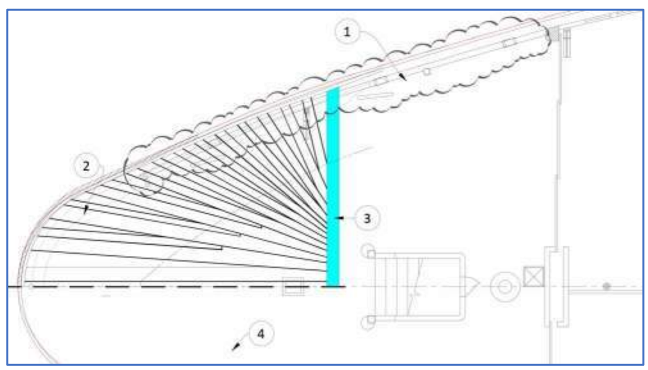

Figure 6: Radiating Fan Timbers

Item 1: Area with advanced rot. 2: Fan Timber Deck Beam - supporting sponson deck 3: Transverse support beam, 4: Deck

In some instances, the decay was so advanced that portions of some timbers are missing and allow one to see through the missing structure to the water below. Rot has permeated into some of underlying deck beams where they exit the sheer.

These beams are designed to support the rub rail and apron outside of the bulwarks, which is further supported with hanging knees and sponson support timbers (see Figure 5). Notably the rub rail was observed (Figure 5: Details of Rub Railing) to be in extremely poor condition and many of the hanging knees were found with checks between fastener, running rust emanating from the fasteners (Photo 6) and some when sounded were hollow, an indication that they may be rotted in the center. Most of the decking on the center of the sponson decks appears to be in good condition; however, due to the extensive rot outside the bulwarks it is likely that much of this structure will require extensive reconstruction and stabilization during the vessel's next yard period.

The main deck under the aft stair tower above hold #6 was observed in extremely poor condition. This condition is likely caused by advanced rot in the deck beams located in hold #6 as illustrated in Figure 4 and as further described in Section F. The entry of water under the stair tower in this portion of the vessel is having a severe detrimental effect on the main deck structure and on the structure of the stair tower itself. The problem has compounded over time: The advanced decay in the deck beams under the stair tower has affected their strength as well as their ability to support the weight of the stair tower. This lack of support has resulted in the stair tower settling, which in turn has caused the joints at the deck and in other parts of the stair tower to separate The opening up of these joints has created additional pathways for water to enter the structure thereby exacerbating the conditions that promote rot.

Sponson Deck Rub Rails

Although the rub-rail was almost entirely renewed during the 1993/94 drydocking of the Eureka, we found that the new rub rail has advanced decay for most of its length. The conditions appear to be worse on the port side or outboard side of the vessel adjacent to the vessel's mooring dolphin fender. The hull constantly comes in contact with the fender during normal wave action, which actively stresses the hull in this area.

The inboard side of the apron and rub rail was also observed with advanced rot. Water intrusion is likely coming from the timber seams that have opened up due to fluctuations in the timber moisture content. See Photo 22.

An examination of the underneath side of the apron and rub rail deck also revealed numerous locations with advanced rot, which indicate the entire structure is compromised. See Photo 23.

The steel handrail that follows the periphery of the port apron deck on the Port (Oakland) side is in very poor condition. The railing is no longer attached to the hull and is pocketed with rust along its length. It no longer provides an adequate safety handhold for NPS personnel performing maintenance on this area of the vessel.

Paddle Boxes

As was noted in 1990, both paddle wheels are again deteriorated and in need of major overhaul. All of the portions of both paddle wheels that are normally submerged are now missing due to corrosion. The U-bolts connecting the wood paddles on the paddle wheel in almost all cases are severely corroded and will require major maintenance.

The Hog Truss lower support beam on the starboard side aft as noted in Photo 10 and illustrated in

Figure 1 has advanced rot. The decay on this beam has advanced to the point where the end of the beam has lost all strength and is caving in. This condition is affecting the strength of the entire truss structure and paddle box support system and must be repaired as soon as possible.

On the outboard side of the vessel the upper sheer plank appears to have advanced decay in spots and will likely need to be repaired or replaced for some length.

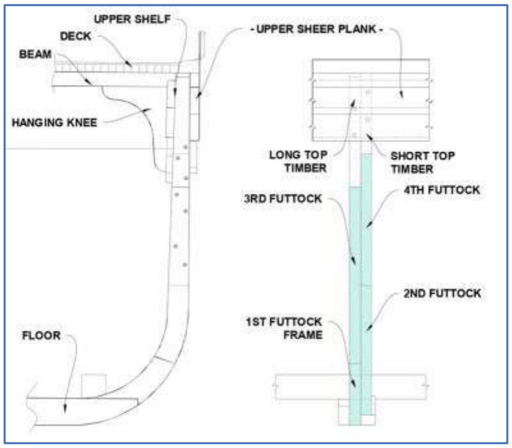

Figure 7: Section of Hull at Paddle

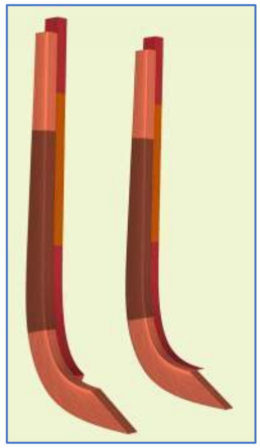

Figure 8: Futtock Frames

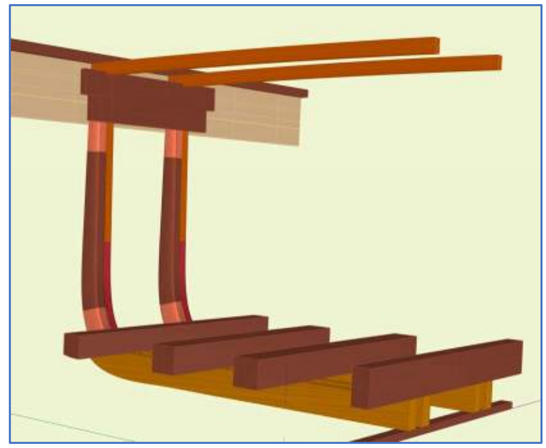

Figure 9: Futtock Frames with Engine Foundations

Photo 10: Rot Pocket Under Hog Truss

(h) Passenger Deck

Description: *The passenger deck was the main passenger space on the ferry. It is 242 long, with a width of 36' at the fore and aft ends and a maximum width of 76' at midships. Most of the passenger deck is enclosed by the house.*

The passenger deck is constructed of 1-1/8"x3-1/4" tongue & groove decking on 2-5/8"x 5-1/2" and 3-5/8"x 5-1/2" deck beams. The deck is supported by the engine room casing and the paddle box bulkheads, and by eight riveted steel girders, four forward and four aft of the paddle boxes. There are two major longitudinal deck stringers, one port and one starboard, made up of four 1-3/4"x 11-1/2" timbers laminated together and supported by steel pillars. Additional smaller stringers are located at the deck edge, at centerline, and at the fore and aft ends of the passenger deck.

The steel engine room casing occupies the center of the passenger deck. There are restrooms for the passengers, port and starboard. These are still in operation, though somewhat modified, for use by Park visitors and staff. Wooden bench seats for passengers are mounted along the port and Starboard sides of the deck inside the house. A restaurant originally occupied the area near centerline and forward of the casing. This has been removed, though portions of the wood partitions that originally enclosed the dining area still remain. Nickelodeons have been placed here, and interpretation panels now hang on the partitions.

Aft of the engine room casing is a small enclosure that served as a newsstand during the latter historic period. This space is now dressed with period magazines and other memorabilia, all visible through the large glass windows at the front of the newsstand.

The centerline area of the deck at the aft end of the house is now a clear space that is occasionally used for events. This area originally had passenger seating and was later the location of a snack bar.

Fore and aft of the house are open deck space's with passenger seating under the overhang of the hurricane deck above. Four lifeboats, each with a set of cantilever davits, were originally mounted here, one at each corner of the deck. These were removed during drydocking in 1984 and only the port aft life boat has been returned to the vessel. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Condition: *The aft end of the passenger deck underwent a major rebuild in 1985 and is presently in good condition. Pillars, stringers, deck beams, decking, and canvas deck covering were renewed. The forward end of the passenger deck is presently rotten throughout and requires comparable treatment. (Completed in 1998)*

Within the house minor rotten areas are seen in the interior tongue and groove sheathing, window sills and frames, panels and trim pieces, and internal studs in the sides of the house. Several passenger deck beams end and sections of the deck planking at the deck edge, are also rotten. This decay is the result of rainwater seepage entering through the sides of the house and from the hurricane deck above. Repairs to these areas should be part of an overall rebuild of the port and starboard side of the house. Much of the seepage will be arrested when repairs to the hurricane deck are completed. All other items on the passenger deck are in good condition. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Condition in Dec 2019: We found the passenger deck to be in reasonably good condition. This is an area that Park service personnel are able to easily complete periodic and ongoing maintenance, preservation and restoration work on. The doors to the inside spaces are left open during the day to allow ventilation in the space. The overhead and bulkheads were well coated, and the coating systems was found intact.

The passenger space is fitted with a domed overhead that extends approximately 3' above the normal ceiling. This gives the illusion of an open space due to the lofted ceiling. The domed ceiling is supported with a longitudinal beam on each side of the compartment that runs the entire length of the inside passenger space and forms the header for the bulkhead that separates the bathroom (heads) on each side of the vessel. The centerline of this space is supported by the steel bulkheads that separate the machinery space from the passenger compartment. The remaining portions of the beam are supported with stanchions that separate the passageway with the spaces fixed seating. See Photo 11 below.

Photo 11: Dome Support Beams

Notably, the beam on either side of the passenger deck is not fair[5]. The condition can be described as sagging. Most of the sagging appears to occur on each side of the structure that surrounds the male and female heads and upper paddle wheel structure, both which have significant structural problems. The roof above or deck on the hurricane deck in these areas is displaying signs of movement between the faying surfaces of the structure, which is also indicative of a problem in the structure.

[5] Meaning not straight when sighted by the eye

There are scattered areas of rot in the sashes of the windows in the dome. Moisture readings in the space's ceiling revealed low moisture content indicating the waterproof membrane on the hurricane deck appears to be keeping the water out. That said, there is elevated moisture readings on the outboard side at the 6th stanchion from the San Francisco end of the passenger deck indicating that the membrane in some spots is compromised.

Examination of the aft end (Oakland end) of the passenger deck on the exterior of the vessel revealed some wood defects at the covering boards under the passenger railings. Railings were found in acceptable condition; however, there were pockets of rot present in the cap rail on the outboard side in way of the lifeboat station. Additionally, pockets of rot were discovered in the covering board on the periphery of the stairs leading to the car deck below. See Photo 16 & Photo 17.

On the exterior of the passenger deck we found rot in some of the overhead (Hurricane deck) structure and in the lifeboat davit support structure.

The exterior decking surface was found in good condition with little to no buckling or tears in the surface.

Rot was discovered outboard of the railings and along the outboard side of the vessel. The rot was not only affecting the trim but also appeared to have worked its way into the underlying structure. All of the structure in these areas will need to be reconstructed to keep the water out of the house.

(i) Hurricane and Dome Deck & Pilothouses

Description: *The hurricane and dome decks are open decks that form the roof of the house. The dome deck is 42'x134' and is approximately 3' above the hurricane deck level. The walking beam assembly and the smokestack protrude through the dome deck on the centerline. Both decks are constructed of tongue and groove decking on 1-3/4"x 3-1/4" deck beams, supported by a series of longitudinal wood stringers on wood pillars. The deck were originally canvas covered but were more recently covered with layers of fiberglass and roofing tar. There are clerestory windows around the perimeter of the dome deck. An iron railing encloses the hurricane deck. The pilothouses are situated at the fore and aft ends of the hurricane deck. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)*

Condition: *With the exception of the local areas of decay, the hurricane deck, dome deck, and the two pilothouses are in good structural condition.*

A series of deck beams at the forward end of the hurricane deck, port and starboard, are weak due to improper repair scarfs. In addition, there is localized rot in beams, and the support pillars are weakened. These conditions combined may eventually make this area of the deck unsafe under a load.

Rot is seen in various locations along the edges of the hurricane deck, and covering boards on both hurricane and dome deck are rotten in places. Repair of these areas is in progress.

The roof of the men's room is rotten along the outboard edge. Some repairs have been made, but a total rebuild will be needed. The canvas deck covering on both men's and women's rooms was renewed in 1986.

Local areas of rot are seen in the wooden trim on the forward pilothouse, all of which require only minor repairs. The steel handrails along the perimeter of the hurricane deck are unsafe due to wastage, and should be replaced.

The fiberglass and tar covering on the hurricane deck is in the process of being replaced with a layer of plywood covered with a modern roofing system which simulates the appearance of the original canvas deck covering. The roofing system is also being applied around the perimeter of the dome deck. All rotten deck structure and covering boards are being replaced as part of this work. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Condition in Dec 2019:

The condition of the hurricane deck can be broken down into several important features. First, the hurricane deck structure. Second, the waterproof membrane on the lower and upper (domed) roof. Third the clerestory windows surrounding the domed structure, Forth, the forward and aft pilothouses and lastly the domed structure above the male and female heads.

Hurricane deck structure:

Overall, the hurricane deck appears to be in good condition. Moisture readings obtained from under the deck (in the passenger space) for the most part revealed M.C. under 20%. Where the moisture readings were high, they were easily attributed to rainwater leaking from the hurricane deck and in almost every case emanated from the area where the structure makes the transition to the domed deck.

Some movement in the structure's gussets were observed in the transition between the clerestory window structure and the domed roof. See Photo 24. That obvious separation between the faying surfaces is in an area where the roof line is sagging and where elevated moisture readings were present. The location is just above the 6th stanchion on the outboard and San Francisco end of the vessel. This distortion might be caused by the support wire stay for the vessels exhaust stack which appears to be jacking the structure up in an area just aft of the area of concern. Regardless of the reason, the situation has caused separation between the roof membrane and the structure allowing water entry. Sounding the deck (membrane and underlying deck) did not reveal any soft spots however, this area should be opened up during repairs and examined further.

The covering board surrounding the domed roof on the hurricane deck was found to have advanced rot in several areas including surrounding the flashing installed to protect the upper end of the four king posts as well as in some area of the half round located on the outer edge of the covering board. The covering board among other uses is used as the lower stay attachment for the exhaust stack guy wires.

As noted in Photo 12, the covering board wood was found punky and soft with a high moisture reading. See Photo 25.

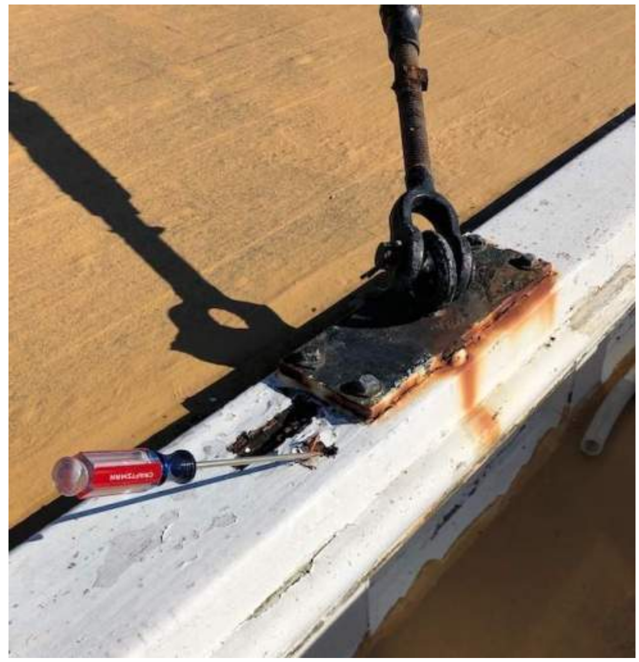

Photo 12: Exhaust Stack Lower Stay

Waterproof Membranes

An examination of the roof membranes found them in relatively good condition. At the time of the inspection, Park Service personnel were in the process of repairing a small section of the roof on the aft inboard side of the vessel.

Figure 10: Roof Membrane and Sealing

The material being used is similar in all respects to that described in 1990 and appears to be holding up fairly well. The product is manufactured by Davlin Coatings of Berkeley, California. The products were a composite of reinforcing membrane

sandwiched between Acrylast Asphalt 900. After that sets the area in question is coated with Acrylast Asphalt 600 deck paint and the topcoat is Davlin Sunshield 3800. See illustration in Figure 10.

Overall the membrane was found in good condition except as previously noted in the areas where there is separation in the transition to the domed roof. See Photo 26.

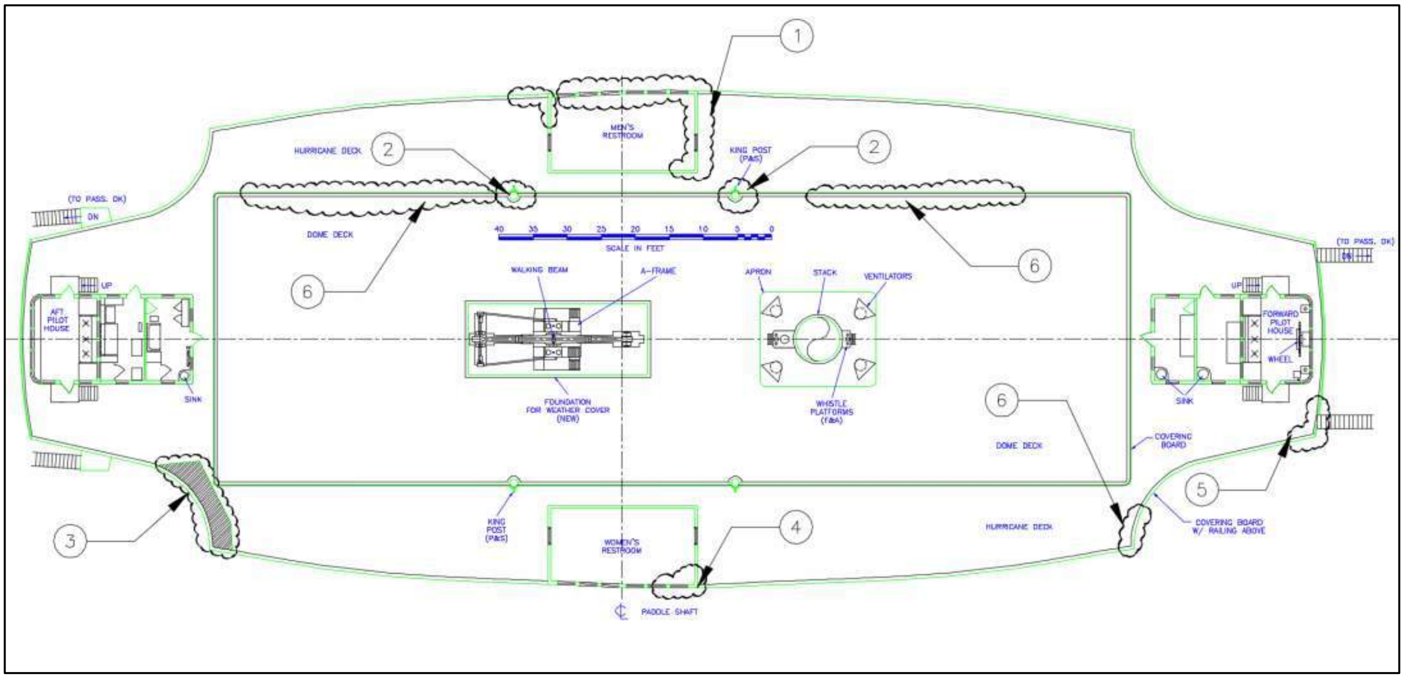

Figure 11: Rot Locations on Hurricane Deck

Standing water was observed in several areas on the hurricane deck roof surface including in the area forward of the male head on the outboard side of the vessel. Water in this area has permeated the structure and as noted in the 1990 condition report there is extensive advanced decay in this area.

Clerestory Windows

The periphery of the domed passenger deck roof is fitted with windows with, in some cases, etched glass. (See Photo 11) The sashes and wood structure surrounding many of the windows was found in sound condition; however, there are numerous window sashes that were observed with extensive advanced decay. Some were so bad that the wood was caving in under its own weight. This condition is a direct result of water not properly draining off the structure and is affecting the underlying structure. (see Photo 26, and Photo 27)

Forward Pilothouse (SF Side)

Both the forward and aft raised pilothouses comprise an enclosed operating or helm station and a cabin, which sits directly behind and slightly below the raised pilothouse platform.

An examination of the forward pilothouse roof showed advanced rot surrounding the covering board around the periphery of the roof membrane. Moss is growing on the membrane; there were elevated moisture readings around the accessible portions of the roof; and the wood under the waterproof membrane was soft and punky in places from rot. The M.C. on the cabin roof was measured at 10% and overall was found in good condition. Some rot was noticed at the corners under the pilothouse roof overhang, but that rot appeared limited to a small section of the covering board.

Photo 13: Left Rear Corner of Pilothouse Roof

The interior of the pilothouse was found in good condition. There were no elevated M.C. readings on the ceiling, which is a good sign considering the condition of the roof and roof membrane. Both of the forward quarter windows had excessive rot in the sashes. The starboard side was observed with the glazing sagging under the upper sash. Without immediate attention it is likely this glazing will break free from its sash. The smoke detector in this space, while present, was found to be inoperable.

Rot was identified at the base of the pilothouse in the tongue and groove siding from the deck to the lower window sashes

Aft Pilothouse (Oakland Side)

An examination of the aft pilothouse roof also showed advanced rot surrounding the covering board although not to the same degree as the forward pilothouse. Moss is growing on the membrane and there is a buildup of bird droppings that appears to be affecting the coating system on the roof. Elevated M.C. readings were noted around the reachable portions of the roof. Due to the moss and bird droppings the forward portion of the pilothouse roof could not be accessed.

The membrane on the cabin roof is in good condition. The M.C. around the periphery of the roof from the covering board inboard is between

20% and 28% for about 10 inches. This varies and, in some spots, where the M.C. is only high within 2 to 3 inches inboard of the covering board. The covering board itself was found in good condition except on the forward end where it turns into the structure. Advanced rot in this location is visibly detectable. This condition is on both the port and starboard side of the vessel. Moisture content in the middle of the cabin roof membrane was found around 12%.

The interior of the pilothouse on the Oakland side is missing the steering wheel and the space was found in good condition with the exception of some rot located in the sash of the forward quarter window sash on the inboard side of the vessel.

Bare electrical wires were observed in this space, but when tested were not found to be energized. The smoke detector was also found not to be functioning.

Male and Female Head Structure

The domed structure that makes up the roof of the male and female heads remains in critically poor condition. Rot is pervasive throughout the structure's roof and the covering boards are all in extremely poor condition. The wood is soft, punky and in some cases caving in on itself. Importantly, water intrusion in this area is so bad that the carpenter's workshop below the head was observed with running rainwater during one of the several storms that occurred during my examination. The Park Service carpenter has been dealing with this for years and has plastic drapes that cover all of the tools and equipment in the carpenters shop to deal with the water intrusion. Notwithstanding the inconvenience to NPS personnel, the larger issue is the structure remains in extremely poor condition and lack of maintenance in this area has not checked the environmental conditions that were observed in 1990. Specifically:

> *The roof of the men's room is rotten along the outboard edge. Some repairs have been made, but a total rebuild will be needed. The canvas deck covering on both men's and women's rooms was renewed in 1986.* (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

While the male head waterproof membrane appears to be in good condition, there is soft wood under the current membrane and the outer edge of the structure as noted above has extensive rot present. In conjunction with the rot found in the covering board and the observations from 1990 it is highly likely the entire structure will need to be restored. (See Figure 12)

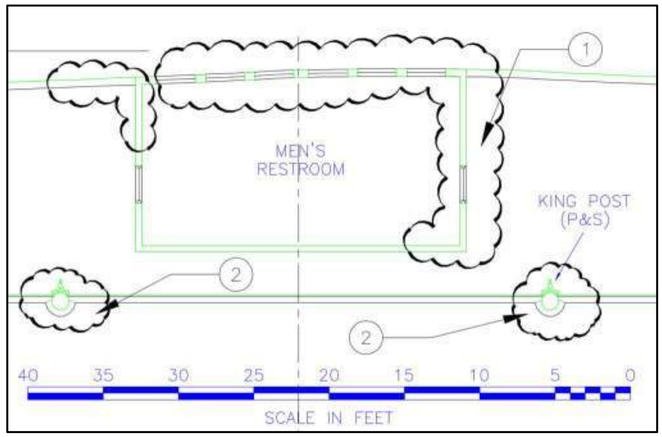

Figure 12: Location of advanced rot in men's head structure

Importantly, the conditions noted above are not exclusive to the male head. The female head on the inboard side of the vessel is suffering some of the similar problems albeit to a lesser degree.

(j) House

Description: *The house is a lightly-framed superstructure that is 192' long at the main deck level, 132' long at the passenger deck level, and is approximately 20' in height from the main deck to the top of the dome deck. It is constructed of 4"x4" studs and sheathed inside and out with ¾ x 3-3/4" tongue-and-groove sheathing. The sides of the house do not provide structural support for the upper decks (the decks are supported by wood and steel pillars), but serve to enclose the automobile and passenger spaces. The house is lined with*

windows at the main deck and passenger deck levels, 44 and 32 per side respectively. A continuation of the bulwark cap rail runs the length of the house below the main deck windows. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Condition: *The house has undergone periodic rebuilding since the early 1960s. Most recently, the aft end of the house has been rebuilt. The forward end is presently extensively rotten, particularly on the port side. Interior and exterior sheathing, window sills and frames, cap rail, covering boards, and internal studs are rotten variously.* The primary cause of this decay is fresh water seepage into the numerous seams and butts in the sheathing moldings. The rotten covering boards and deck edge structure of the hurricane deck above is also contributing to the decay by allowing rainwater to enter the structure.*

**rebuilt from dome to paddlebox in 1997 and 1998*

The house will require extensive rebuilding to repair existing damage. In addition, measures should be taken to extend the life of the house structure, and thereby eliminate the need for frequent repair. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Condition in Dec 2019:

The deckhouse exterior was determined to be in extremely poor condition. The inboard side of the house is not in as poor condition as the outboard portions but still requires serious maintenance. The Tongue & Grove (T&G) exterior siding is stained, dirty and covered with mold and moss. Parts of the accessible portions of the exterior are showing signs of paint failure and in some areas advanced rot. The outboard side of the vessel is easily worse. Parts of the structure are without siding and rot is extensive from the covering board on the men's head to the bulwark cap or apron platform that surrounds the vessel at the sheer. Window sashes are in need of repair and will require replacement.

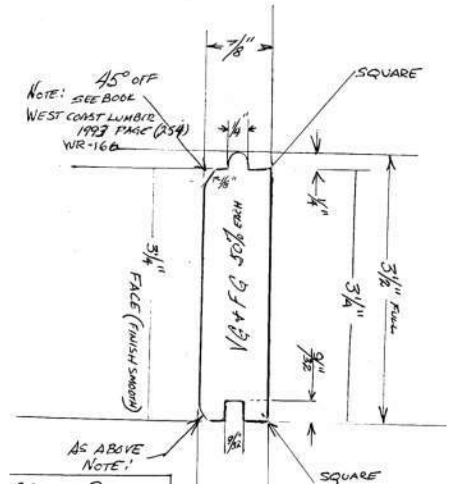

Figure 13: Tongue & Groove Siding Details

The siding covering the paddle wheel box appears to be in worse condition and due to the conditions present it is likely the entire outboard side of the vessel will require extensive restoration and stabilization. Historic records reviewed revealed the siding is cedar T&G as dimensioned in Figure 13.

(k) Stack, A-Frame, and Walking Beam

Description: *The stack and A-frame are all-steel structures that originate in the engine room and project up through openings in the dome deck. They are exposed to the weather at their upper ends. The cast iron walking beam sits atop the A-frame. Below the dome deck, the stack and A-frame are enclosed by the engine room casing. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)*

Condition: *The stack, A-frame and walking beam are presently undergoing preservation.*

Stack: Before being removed for preservation in 1989, the stack was severely weakened due to corrosion and was in danger of collapse. Ongoing preservation work includes welded repairs, and sandblasting and coating. The wire-rope stack guys will be renewed.

A-frame: The riveted steel A-frame is in good condition where it is protected by the house, but is rusting at the upper end. The two steel platforms

mounted at the top of the A-frame are severely wasted and will be replaced. The A-frame will be hand-scaled and painted.

Walking Beam: The massive walking beam is rusting in local areas where paint has broken down but is in good condition. It is scheduled to be hand-scaled and painted. The brass oilers on the walking beam and cross-head have been cleaned. A canvas seasonal cover has been fabricated to keep rain out of the engine room during the rainy season, and appears to be effective in protecting the walking beam as well. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Condition in Dec 2019:

The stack, A-frame and walking beam were not examined as part of this report and therefore their conditions is not discussed.

Section A.6 Piping Systems

Description: *EUREKA's piping consists of inactive historic systems, and systems installed for museum usage.*

Condition:

Steam and Feedwater Piping: These systems comprise the majority of the historic piping, and are primarily confined to the engine room. The systems are inactive, and portions of the piping are visibly deteriorated. Much of the steam piping is insulated with asbestos.

Bilge and Fire Systems: EUREKA is equipped with a fire fighting system consisting of a 1-1/4" water line feeding several fire stations, each with canvas fire hoses. Water pressure was originally provided by steam-powered pumps, but is now provided by a 4" electric pump that was installed in the engine room during the 1970s. Water is supplied from a sea chest located near the pump, and from a fresh water shore connection. The pump is operational, though the sea valve leaks when in the open position. The condition of the fire system piping is not known.

In 1988, bilge pumping and alarm systems were installed, including emergency suctions in all holds (with exception of the peaks) and automatic stripper pumps in all hull compartments. The emergency bilge system is powered by an electric pump located in the engine room, and uses the historic hot well as a bilge water holding tank. This system is not connected to the fire system.

Fresh Water: Fresh water is piped aboard to supply water to the restrooms, the crew's sink in the Hold #5, and the sink in the stern pilothouse. Wastewater is piped ashore after being processed in a holding tank located in Hold #5. Most of the existing freshwater system is non-historic, although some original fixtures and plumbing are used.

The freshwater system is in generally adequate condition. Decay in the wood structure around plumbing in the men's room may indicate leakage. The plumbing will need to be replaced when the men's room is rebuilt. The wastewater system has a flaw in that failure of the transfer pump could result in overflow of the system. This can be corrected by installing a warning alarm. (Don Birkholz, Jr. Tri-Coastal Marine, 1990)

Condition in Dec 2019:

The piping system examination did not cover all of the vessels contemporary piping systems due to the fact most of those systems had been removed from service. Instead the focus was placed on the bilge and fire systems. Potable water, black and gray water systems have all been removed or decommissioned.

The vessels dewatering system is consists of a PVC pipe that serves each bilge on the vessel. The system terminates in each space where there is a combination of a suction strainer and has one or in some cases several AC powered submersible sump pumps. The sump pumps are plumbed into the PVC bilge pipe with a check valve to prevent backflow.

The space pipe leads to the engine room manifold and a AC powered bilge/fire pump. Reportedly the pump functions; however, it is not self-priming and therefore will not take suction from any of the spaces when energized unless it is first primed.

Overall the PVC pipe and the bulkhead terminations appear to be in good condition. That said, overall the system lacks any real capacity especially considering the damage stability of the vessel.

The fire side of the piping system remains in place but is not usable as none of the fire stations are fitted with fire hoses or nozzles.

Section A.7 Electrical Systems

The existing electrical system on the Eureka provides power to lighting circuits, to AC outlets located sporadically throughout the vessel, to the vessel's sole fixed fire/bilge pump, to submersible bilge pumps in each compartment, and, at one time, to provide power for the fire detection and suppression systems. Incoming power is provided through a shore tie connection on each bow of the of the vessel on the inboard side.

Lighting

The present lighting system is supplied with power through two main lighting panels. They are located in two storage spaces on the passenger deck adjacent to the male and female heads. The panels are located inside the space and likely do not meet code requirements due to their location.

Last Electrical Survey

The last known electrical survey of the Eureka was completed on 30 October 1992 by Designers & Planners, Inc of Arlington, VA. That report outlined the results of a survey that included the following components:

- Detailed inspection of the electrical system to analyze possible deficiencies.
- Measure the electrical system and all system components to develop as-built construction drawings.
- Prepare as constructive drawings of the system detailing deficiencies and damage; prioritize repair items.
- Perform electrical tests and computations to determine a system condition and repair requirements.
- Develop preliminary cost estimates and material list for the proposed repair and upgrade, including the addition of a snack bar and additional lighting in the engine room.
- Prepare construction drawings, specifications and material list based upon the above information to bring assistant to the requirements of the National Electrical Code (NEC)

At the time of this examination, the information identified in the report noted above was not available. Additionally, this examination was constrained to a visual examination of the electrical System and components located on the *Eureka* in the as found condition. Electrical resistance readings of the existing AC electrical system were not performed as part of this examination. Problems were observed that in some cases require immediate attention and in other cases should be corrected as part of the upcoming Eureka stabilization project. Some of the conditions include exposed bare wires, openings in existing lighting and power panels, electrical conduit with excessive corrosion, and in some cases, no longer properly attached to the structure.

Section A.8 Fire Fighting Systems

Fire Sprinkler System

In 1997 the National Park Services contracted Designers & Planners, Inc of Arlington, VA to design and install a water-based fire protection system on the *Eureka*. The system was designed to meet the requirements of NFPA 13 (1994), Department of the Interior Standards for Historic Vessel Preservation Projects, State of California Uniform Building Code (UBC) 1996, and the City of San Francisco UBC Amendments.

The system was designed as a wet sprinkler system with automatic sprinkler heads. The system originally was intended to be a wet system under

pressure and connected to a city fire hydrant located on the pier and adjacent to the vessel's normal moorings. Designed and installed as passive fire protection for the vessel where water discharges immediately from the system sprinkler heads when activated (opened) from the heat of a fire. The original strategy of the system's piping runs was designed to closely follow the transverse beams to hide the piping system from public view. This system was designed to allow close conformance to the Department of the Interior Standards for Historic Vessel Preservation Projects as much as possible while providing passive fire protection. The system was installed with 12 active fire zones.

The wet sprinkler was equipped with a monitoring system that when installed monitored the vessels primary electrical power, city fire main pressure, loss of flow after initial sprinkler discharge, sprinkler activation in any of the 12 fire zones, and low battery voltage for all equipment requiring battery backup. The system also included a shore-side standby AC generator that was set up to provide emergency power upon loss of the ship's normal AC power.

At the time of my inspection the entire system had been rendered inoperable. The main water supply connection had been disconnected and the system piping was not charged. The auxiliary standby AC generator was tagged out and the fire system monitoring panel was disconnected. The system as currently configured is not providing any passive fire protection to the vessel whatsoever.

An examination of the piping throughout the ship indicates that the condition of the piping depends on where in the ship the pipes are located. Piping that had no coating system in place was found with everything from minor surface rust to flaking rust. According to park records (Eureka Fire Supression System Contract, 1997), the interior piping was schedule 40 and exterior pipe was required to be protected by hotdip galvanizing or extra heavy schedule. Since most of the exterior pipe was coated it was not confirmed if the exterior pipe was galvanized. Notably, the exterior pipe with little exception was observed in good condition. Presumably due to being protected by the coating system. For the piping components inside the vessel the condition of the piping was noticeably worse. The forward peak and hold bilge compartments were determined to be in the poorest condition. Likely, the reason for this difference is the relative high humidity normally found in these spaces. The corrosion problem was not limited to just the piping system components. Where the pipe brackets were attached to the vessel's timbers, there was noticeable corrosion, again more so in the lower portions of the vessel especially where the wood had a high moisture content. The high M.C. of timbers creates an ideal condition for corrosion where metal contacts wet wood.

Fire Detection

In addition to the wet sprinkler system, the vessel's fire detection system has also been disabled. As a work-around, the NPS personnel have installed battery operated modular smoke detectors throughout the vessel. No list was available to determine how many were installed; their locations; when their batteries had been renewed, or when they had last been tested. This poses a problem as during my examination I discovered that the several smoke detector in both pilot houses did not work and the smoke detector in the Captain's cabin (cabin aft of aft pilot house) was chirping due to a low battery.

Section A.9 Fasteners

Description:

In general terms, the strength of the *Eureka* depends on all parts of the vessel's structure. It has been said that of these parts, none are more important than the joints and fastenings. (Department of the Navy, 1957). The Coast Guard states that for a commercial vessel: *"A boat is no better than its fastenings"* (USCG, 1995)

Eureka's mechanical fastening system comprises nails, spikes, screws, lag screws, drift bolts, bolts over clinch rings, and double ended bolts. Like any wood vessel of any length, the *Eureka* has many

types of fasteners used in its fastening system. There are over 25,000 plank fasteners, 15,000 ceiling fasteners, 2,000 futtock frame fasteners, hundreds of backbone fasteners, easily a thousand bolts for the clamp and shelf structure and 20 to 30 thousand deck fasteners. In addition, during the 1993/94 drydocking it was recorded that there were over 240,000 fasteners holding the copper sheathing on the vessel.

Photo 14: Salt Deposits on Bilge Fasteners

In March 2018, the United States Department of Agriculture performed an assessment of fastener corrosion and salt damage in the bilge of the *Eureka.* The discussion on corrosion in that report stated: *"when wood moisture content (M.C.) is below 15% to 18%, embedded metals do not corrode. As the moisture content increases above this threshold, the corrosion rate increases rapidly with increasing moisture content before plateauing at a maximum corrosion rate at approximately 30% M.C."* (Zelinka & Kirker, 2018) Their study goes on to discuss other factors that affect corrosion. But what is important here is that the report states that the mean moisture content of the wood in the *Eureka* is 45%, indicating that *Eureka*'s fasteners are continually corroding.

In addition to the conclusions the Department of Agriculture made regarding the M.C. of the vessel's timbers, the report also discussed the phenomenon of white deposits (crystal substance) building up or growing at the exposed heads of fasteners in the lower portions of the vessel's bilge, a condition that can be seen in Photo 14. Note that the wood surrounding the fastener in Photo 15 is damaged.

After their evaluation of the white deposits the Department of Agriculture concluded that the crystals "appeared mostly amorphous but contained some cubic crystals. Energy Dispersive X-Ray Spectroscopy (EDS) confirmed that the cubic crystal were indeed crystals of rock salt (NaC1). The amorphous region was predominantly sodium chloride with iron in it as well. (Presumably from the corroded fasteners underneath the surface)." (Zelinka & Kirker, 2018)

Due to the chemistry involved, a discussion of the fasteners in the *Eureka* cannot be completed without a discussion of both the corrosion of the metal fasteners and the buildup of crystals around the fastener heads.

During my examination of the *Eureka*, I noted that the M.C. exceeded 30% for all readings taken of planks, keelsons and side keelsons below the waterline. Moisture content of the internal ceiling depended on whether water was leaking onto the timbers from leaks in the deck. Where there were leaks, the M.C. exceeded 30%, if not, the M.C. was around 20%. This was also true of other wood structure, reinforcing the conclusions found in the Department of Agriculture's report.

Photo 15: Wood Damage in the Vicinity of White Crystalline Deposits

For the white crystals, there are two separate conditions that, due to the age of the vessel, are easily conflated, but which are closely connected. First, seawater (in this case, the seawater that saturates the wood below the waterline) contains a number if dissolved salts, and while usually they are found in small concentrations, for the *Eureka*, *"they can become concentrated in within wood. Particularly near the waterline where evaporative water losses can concentrate salts."* (Jagels, 1992) The *Eureka* presents the perfect environmental conditions for the formation of salt crystals through evaporation. The second and larger concern is that salt crystal formation is also a byproduct of a chemical reaction that occurs in wet wood adjacent to a metal fastener that is corroding.

One byproduct of that corrosion is hydroxyl ions that build up at the exposed head (which is the cathode of the corrosion cell). This process concentrates alkaline chemicals in the wood near the fastener head and these chemicals degrade the lignin (the binding resin) of the wood, adjacent to the fastener head, by a process called delignification. In addition, acidic conditions develop along the ~~fasteners~~ shank (which is the anode of the corrosion cell). These conditions can hydrolyze the cellulose (the structural fibers of the wood) thus weakening the wood surrounding the fastener shank. See Photo 15.

When the alkalai formation occurs at an external underwater cathode or when an exposed fastener head is submerged in bilge water, the free water usually dilutes the chemicals before the wood is damaged. However, in the case of the *Eureka,* most of the exposed fastener heads are not exposed to free water. Therefore, we see damage due to that chemical buildup. Photo 14 shows the results, which are typical.

Thus, many of the vessel's 200,000+ fasteners are suffering from corrosion, and the wood surrounding these fasteners is suffering from some level of deterioration. In the case where the fasteners are in wetter wood, corrosion is predictably more severe than where the timbers have a moisture content below 15% to 18%. The numbers provided include the plank fasteners that were reportedly renewed during the vessel's last drydock. This is due to their age and present condition of the vessel at large.

Condition in Dec 2019:

During the 2019 examination of the vessel there were numerous indications that the fastening systems on the *Eureka* were in critical condition. Fasteners in the lower frames were noted and, in some cases, were found to be corroded down to a small fraction of their original diameter (Note that a fastener corroded to half its original diameter has lost 75% of its cross-sectional area, and thus 75% of its strength.) The same condition was observed in the exterior hanging knees and in the upper and lower sheer clamps in both peak compartments on the vessel. Steel fasteners bleeding rust were noted on the interior and exterior structural components.

As noted previously one of the exterior knee fasteners was removed and sent to Anamet Inc for examination and analysis. On February 6, 2020 Anamet provided their report on the analysis of the fastener in question[v]. The following points are provided to help illustrate the condition of the fastener in question:

- The report indicates the chemical properties of the fastener are consistent with that of AISI 1020 Carbon steel.
- Testing revealed that the mechanical properties of the fastener were actually stronger in both tensile, yield and elongation as well as hardness.
- The fastener had undergone significant corrosion resulting in wall loss
- Examination by energy dispersive x-ray spectogrophy and Scanning electron microscope indicated that the primary constituents of the corrosion products were iron (Fe) and oxygen (O); carbon (C), and chlorine (Cl) were also detected. Sodium (Na) was detected in the orange corrosion product while sulfur (S) was detected in the brown corrosion product. The corrosion product on the fastener surface was likely iron oxide and sodium chloride (salt)

While the mechanical properties of AISI 1020 Carbon steel would normally be strong enough for the joint connections on the *Eureka*, the excessive loss of wall thickness represents an unacceptable loss in the strength. The loss in strength of the fastener means there is a loss in the strength of the joint.

Importantly, regardless of the condition of the fasteners or the degradation of the wood surrounding the fastener the bigger problem is that *"corrosion of the fastener combined with deterioration of the wood causes loss of strength of the joint and weakening of the structural integrity of the assembly"* (Baker, 1980). In this case the assembly is the *Eureka's* structure.

Lastly, as noted in Section C. Hydrostatic Analysis of the Ferry *Eureka*, while there is a low probability of hull girder failures due to the strength of the timber alone *"the fasteners and other structural connections are another matter"*

Section A.10 Recommendations

The following recommendations are based on the results of the physical examination that was completed on the *Eureka* in late 2019 and early 2020. The breakdown of the items listed follow Article II paragraph C. of Exhibit A of the Scope and Cost – *Eureka* SAFR 229380.

1. **Ship:** *Relocate the ship to a facility or facilities capable of lifting the ship out of the water for inspection and which has the site capacity and skill set to conduct major wooden ship construction. The wooden ship weighs over 1 million pounds, is 299 feet long and 80 feet wide. While the ship is lifted out of the water the underwater hull copper cladding will be evaluated.*

   1.1. Prior to relocating the vessel, the following conditions should be met:

      1.1.1. Towing plan should be developed to ensure the safe transportation of the vessel to the repair facility.

      1.1.2. Watertight bulkheads should be examined, reinforced, and made watertight to the main deck.

      1.1.3. High capacity pumps should be pre-positioned on the vessel with the capability to pump the three largest compartments on the vessel.

      1.1.4. Assuming that *Eureka* will be docked in a floating drydock, if possible, the drydock should be brought as close as possible to the *Eureka's* vessel's normal moorings to reduce any risk to the hull, port or environment.

   1.2. Vessel weight: The current summary description and key elements states the vessel weighs over 1 million pounds. Per Section C, it should be noted that current estimated weight of the *Eureka* is closer to 3.5 million pounds.

2. **Outboard Repairs:** *Apply a corrosion resistant flexible bonding to the wooden hull's copper sheathing if necessary based on evaluation; Replace planks and caulking on planked wooden hull seams and paint wooden portion of hull with a durable marine-grade coating; Repair/replace portions of the damaged and sagging wooden fender around the ship's perimeter and paint entire rail; and tighten the cantilevers (support brackets) that hold the large sagging overhanging decks.*

   2.1. **Copper Sheathing Evaluation:** Based on the examination of the copper sheathing at the waterline and marine growth just below the waterline, it should be assumed that the copper sheathing requires renewal. This likely means that the NPS will need to plan for one of several contingencies to ensure the protection of the planking below the waterline of the *Eureka* is sustainable.

   2.1.1. Contingency 1: Determine if the Copper sheathing can be renewed without violating recently enacted environmental laws. This is due to the fact that in July of 2018 the State of California enacted strict regulations governing the use of copper in the bottom paint on recreation vessels. Essentially, the law prohibits copper-based anti-fouling paints with a leach rate above 9.5 micrograms per square centimeter per day. It is assumed that submerged bare copper sheathing, submerged, exceeds this threshold and therefore could be in violation of that statute. NPS legal staff should evaluate if this state law affects the replacement of the copper sheathing on the *Eureka*. (State of California, 2020)

   2.1.2. If the copper can be renewed, then the work item will include the removal of approximately 12,345 sq. ft. of copper sheathing panels and approximately 240,000 nails. This work item should include the replacement of the copper sheathing on both rudders, which is in addition to the numbers provided.

   2.1.3. Contingency 2: Determine a suitable replacement that will provide protection to the underwater wetted area of the hull planking until the next scheduled drydocking of the vessel. This will require a commitment on the out of water maintenance cycle of the vessel to prevent worm damage to the hull. Replacements might include C-Flex® or the Allan H. Vaitses - Covering Wooden Boats with Fiberglass.

   2.2. Due to the anticipated condition of the underwater plank fasteners, the NPS should anticipate that the fasteners installed in the 1993/94 drydock are also now at the end of their service life. The fasteners that were not examined or replaced at that drydock, will likely in some cases be missing altogether due to their age and the effects of corrosion. Therefore, the planking will likely require to be completely refastened. It is estimated that this will total over 40,000 fasteners. Due to the conditions observed in the vessel's futtock frames any refastening of planking cannot be completed unless the attaching frames have been repaired or replaced. See item 3.1 for additional details.

   2.3. Repair/replace between 10 to 20% of the planking on the underwater wetted area of the vessel. This is based on the concern that some of the copper sheathing has been compromised due to the vessels age and visible growth on the hull under the waterline. The assumption, there is worm damage to some of the vessels planking below the waterline.

2.4. Upon replacement and refastening of the vessels planking, re-caulk all seams under the waterline and in the topside planking:

2.4.1. Approximately 16,600 linear feet for the bottom planking, and

2.4.2. 6,260 linear feet in the topside planking. *(Numbers based on last drydock)*

2.5. Removal of existing exterior coating system above the waterline where the copper sheathing starts, prep and paint hull to conform to historical color scheme. Approximately 4,200 sq. ft. of side shell and 7,000 sq. ft. of sponson/rubrail and support structure. *(Beams, sponson supports, hanging knees, etc.)*

2.6. Repair and stabilization of the rub rail and underlying support structure surrounding the periphery of the vessel. This includes:

2.6.1. Repair of rot in exterior rub rail on both port and starboard side of vessel. Including 600 linear feet of outer covering board, outer rub rail, inner rub rail, filler blocks, and bottom stringer.

2.6.2. 200+ linear feel of chafing strap,

2.6.3. Replacement of approximately 20 deck beam ends on each side of the vessel by scarfing to previously approved NPS Standard. These deck beams are currently suffering from advanced decay at their ends where they form the vessels rub rail, see Figure 5: Details of Rub Rail.

2.6.4. Examination of the hanging knees in conjunction with the refastening of these structural components for signs of rot or other defects such as checks through the fastener line. Repair or replace as needed. NPS should anticipate that 10 to 20% of the exterior knees will require extensive repair or replacement.

2.6.5. Replacement of the inboard spring beam that supports the rub rail, paddle wheel box and house structure outboard of the paddle wheel box.

2.6.6. Spot blast steel outer paddle bearing supports to remove accumulated rust then prep, prime and recoat steel to preserve condition. Provide report of condition to NPS following blasting indicating existing condition of box beam and remaining service life.

3. **Hull and Exterior Work Repairs:** *Provide for the repair and or replacement of rotted deck frame and planking components, stanchions and knees, outboard framing and perimeter rub rails; selected damaged windows and window frames will be repaired or replaced. The blocking and fastening of mooring bits will be structurally fortified and, in some cases, relocated. All painted surfaces will be renewed. Replace the second deck stairway, which is collapsing with the underlying deck; Repairs and painting of rotted exterior metal equipment and structures; Replace non-functioning guy wires intended to hold up the smoke stack; Paint and preserve the underside of the car deck; and clean debris from the exterior and paint.*

Hull repairs noted in this section include the stabilization of the vessel's structure including but not limited to frames, floors, sheer and clamp planks, ceiling planking, and their fastenings components. This is in large part due to the condition those components were observed in. For all repairs completed for stabilization, restoration, or preservation as a result of the decay of wood that forms part of the vessel's structure, we highly recommended that those repairs follow the United States Navy recommendations: *"For a high degree of safety, it is essential to mark wood for removal at least 2 feet each way along the grain and 2*

inches across the grain of each member showing an area of obvious decay[vi].

3.1. Numerous frame heads and frame heels throughout the vessel were observed with advanced stages of rot and with weakened fasteners. Stabilization of the vessel's structure will require the repair, and, in many cases, the replacement, of these frame sections and their fasteners. Due to interferences including inside planking (ceiling) and other structural members, a complete assessment of each frame could not be made. Therefore, where advanced rot was observed in the frame heads, it was assumed that the rot was also affecting the adjoining timber. For replacement of double-sawn frames is assumed that it will be necessary to remove a portion of the outside planking both to obtain access for repairs and to assist in the evaluation of the unseen portion of those frames.

3.1.1. Replacement of the Oakland side forward peak compartment frames heads. This includes frames o53 through o61 on the starboard side and o53 through o61 on the port side of the vessel.

3.1.2. Removal of the Oakland side forward peak breast hook to determine the extent of rot, repair and reinstall after the renewal of the sheer clamps in this compartment.

3.1.3. Replacement of the SF side forward peak compartment frame heads. This includes frames s61 through o68 on the starboard side and o61 through o68 on the port side of the vessel.

3.2. Determination on the extent of decay present in the Oakland side stem above the keelson. This should be completed in conjunction with plank removal to access the frames in this area of the vessel. *Note: this item was also identified during the 1993 drydock.*

3.3. Upper and lower sheer clamp in the aft forward peak compartment were compromised on both sides of the vessel and will require renewal to stabilize the vessel's strength. This condition is also present in the forward peak and in several of the vessels holds. The scope of the work for this line item should include a minimum of a 120 linear feet of upper and lower heavy sheer strake planks in various compartments. This recommendation covers the sheer planks in each of the vessel's bow compartments. New sheer planks should be scarfed into existing sheer clamps with a minimum of 12:1 scarf joint ratios and with nibs. Upper and lower sheer plank strake joints should be overlapped a minimum of 5 frames.

3.4. Replacement of numerous frames heels which in some instances includes the 1st and 2nd futtock. It should be assumed that approximately 65 to 70% of the vessel's frames will need extensive repair at the head or heel of the frame. Frames repairs will be required in the following compartments:

3.4.1. Aft peak

3.4.2. Juniors Hold

3.4.3. Hold #2

3.4.4. Hold #3

3.4.5. Machinery Space

3.5. Evaluation and repair of corroded hogging straps. Original thickness are reported to be 0.75" thick (t) and on 23 November 1993 were recorded at 0.50"t. with some rusted completely through. This condition has worsened since 1993.

3.6. Refastening of structural components. Due to the age and condition of the backbone fasteners, the NPS should anticipate the renewal of 90% of the

vessel's structural fasteners. This will include:

3.6.1. Refastening of the exterior and Interior hanging knees. Each knee is secured to the vessel with between 14 to 18 bolts.

3.6.2. Refastening of the Keelson and machinery foundations

3.6.3. Refastening a portion of the Interior ceiling

3.6.4. Refastening of the watertight bulkhead connections.

3.6.5. Refastening of the Watertight bulkhead planks

3.7. Rebuild outboard paddle wheel enclosure and structure surrounding the male and female heads including the section that forms the roof of the heads.

3.8. Remove and replace the entire exterior tongue and groove siding on the outboard side of the vessel. Perform a visual examination of the underlying structure and repair as deemed necessary. This work should be accomplished in conjunction with the rebuilding of the male and if necessary, the female head structure.

3.9. Remove and replace 10 to 30% of the exterior tongue and groove siding on the inboard side of the vessel. Perform a visual examination of the underlying structure and repair as deemed necessary. This work should be accomplished in conjunction with the rebuilding of the female head structure.

3.10. Repair and stabilization of the main deck under the Oakland side stair tower. Work should include the replacement (not sistering) a minimum of nine full length deck beams from the collision bulkhead aft in hold number six. Beams are the main support for the Oakland side stair tower. This project includes jacking up and providing temporary support to the stair tower while the flawed deck beams are removed and replaced.

3.11. Rebuild Oakland side stair tower structure.

3.12. Rebuild the forward and aft pilot house.

3.13. Remove defective siding on both pilot houses and replace with new T & G siding

3.14. Stabilize the roof structure of both pilot houses and install new roof membranes.

3.15. Rebuild window sashes in the corner windows for each pilot house

3.16. Redesign and repair mooring points for the vessel on the sponsons and rub rails. Chains and mooring lines should be cordoned off from passengers to ensure their safety.

3.17. Remove and replace the roof membrane on the hurricane deck. This work item should be accomplishing in conjunction with the restoration of the domed structure that forms the roof of the male and female heads, the repairs to the covering boards that surrounds the periphery of the domed roof, and the structure that defines and supports the Clerestory Windows.

3.18. Repair areas on the exposed portions of the passenger deck where rot has damaged the structure. Remove defective timbers and replace to restore the strength and integrity of the structure. This work item should be completed in conjunction with item 3.17 above

3.19. As part of the work performed on item 3.17 above examine the supporting structure surrounding the exhaust stack and the structure that forms the opening for the walking beam A-frame. Repair

this area as needed to ensure the watertight integrity of the structure is maintained for the long-term stabilization of the support structure.

4. **Mechanical and Systems Improvements**: *Remove non-historic obsolete mechanical systems and equipment, including obsolete and excessive electrical service and install minimal and efficient electrical service. The project will install bilge sensors and a high-volume emergency bilge pumping system and install a low volume maintenance bilge pumping system. The existing fire suppression system will be removed, and a new contemporary marine-specific fire detection and suppression system will be installed. A passive and forced air preservation-oriented ventilation and dehumidification system will be designed and installed. Staging and fall protection system on the exterior side of the ship will be designed and installed so that cleaning and maintenance can be performed.*

4.1. Piping System: Further evaluation of the vessels bilge piping should be completed and should include the following:

4.1.1. Determine suitable replacement self-priming bilge/fire pump.

4.1.2. In conjunction with sizing the pump, evaluate the existing piping to ensure the pipe diameters can handle the proposed flow rate for the pump.

4.1.3. To prevent pumping the bilges directly into the Bay, repurpose the existing stainless-steel sewage pumping station including the sump pumps to act as a bilge holding tank. Re-plumb the vessels bilge manifold to this space and direct all nuisance bilge water to this tank and have this tank pump the water to shore. Add capability to measure flow rates and install system alarm function to notify park personnel of excessive pump operations. NPS should ensure this does not violate any local ordinances prior to instituting this change.

4.1.4. Add high level bilge alarm system to the vessel with a high-level alarm in each bilge compartment on the vessel. For the engine room there should be a forward and aft alarm

4.2. Electrical System: It is recommended that a complete electrical survey of the vessel be conducted similar in nature and scope to the one completed on 30 October, 1992 as a precursor to the development of a specification for the fire detection system. The survey should be completed in time so any electrical deficiencies can be included in the final scope of work.

4.3. It is recommended that the passive and forced air preservation-oriented ventilation and dehumidification system called out in section 4 be reduced to just a forced ventilation system. Due to the M.C. in the bottom planking it is highly unlikely that a dehumidification system will be effective in the *Eureka's* bilges

4.4. Fire Detection: The fire detection system on the *Eureka* is virtually nonexistent. The NPS should consider a completely addressable type approved marine fire detection systems based on a broad range of smoke, heat and flame detectors. The system should include manual call points, bells, sounders and lights as well as integrate safety-related functionality such as a pre-tapped public address system that guides the visitors with directions on how to disembark the vessel.

4.4.1. The fire detection system should be fitted with the following features:

4.4.1.1. Transition power supply

4.4.1.2. Remote monitoring

4.5. Fire extinguishing system: Retaining the existing fire extinguishing system should

be considered. The piping for this system is intact and although the system is not operational upgrading the system would likely cost less than removing the existing systems and then reinstalling a newer system.

4.5.1. As part of the renovation of the piping system below the main deck the following items should be considered:

4.5.1.1. Coating all of the pipe, brackets and hangers.

4.5.1.2. Replacement of all hangers with stainless steel brackets.

4.5.1.3. Renewal of the shore connection hose.

4.5.1.4. Hydrostatic testing of all piping to ensure the pipe is satisfactory for continued service.

4.5.1.5. Renewal of the systems monitoring system with a system that integrates with the new or proposed fire detection system.

Section A.11 Conclusions

The *Eureka* presents a uniquely complex structure. The vessel relies on wood timbers connected by steel fasteners and steel hogging straps to remain intact and watertight. Over time all of those components have aged and become less effective. This report documents extensive decay and delignification of the wood timbers, corrosion and substantial strength reduction in the fasteners, as well as extreme corrosion in the hogging straps. Due to the complexity of *Eureka's* construction, this report only documents the findings for portions of the visible hull structure. For example, the outside planking and interior ceiling hide nearly all of the vessel's frames. If the visible areas show extensive structural degradation, it must be assumed that the portions that were not visible are similarly degraded. Therefore, the primary finding of this report is that a substantial portion of the timbers, fasters, and hogging straps on the *Eureka* are in need of replacement or restoration in order to properly stabilize this vessel. The upcoming drydocking of the vessel is extremely important to the long-term viability of this historic monument.

When the *Eureka* was drydocked in 1993/94 extensive repairs were made. Much of that work needs to be redone, not because of faulty craftmanship, but due to the aging process of an old wood boat. Setting an appropriate drydocking interval is an essential piece of the long-term viability of the *Eureka*. While the vessel is essentially a static display, she sits in a hostile environment. The relatively high humidity makes rot a perpetual problem, the salt water will continuously corrode fasteners, and the hull must be constantly protected from the damage of marine borers. (*The last two drydockings of the CA Thayer found substantial marine borer damage.)* The copper bottom on the *Eureka* has likely played a significant role in preventing in resisting marine borers; however, as noted in this report, there are some areas under the waterline with fouling and growth. This is an indication that the copper sheathing is no longer intact and more importantly that the hull in these areas is vulnerable. The drydock cycle for a wooden ship should be based on the capability of its coating system to protect the hull from attack from marine borers. Historically, the interval for larger ships was between 6 to 10 months. Commercial wooden small passenger vessels now operate up to 24 months between drydocks. At the time of this writing, the *Eureka* has not been out of the water in almost 27 years. In 1993 when the vessel was hauled it was 100 years old. Now the vessel is approaching 130 and the costs of necessary repairs continues to rise. In the future, more frequent dry dockings will be necessary to stay abreast of the need for repair and maintenance.

As an alternative to these re-occurring costs, National Park Service should consider another modified *"jacking up the whistle and sliding a new boat underneath"* for the *Eureka*. Instead of doing

a complete stabilization and rehabilitation project on the vessels existing hull, the hull under the car deck could be replaced with a steel structure that matches the vessel's original shape. The structure above the deck beams would be retained to ensure the outward appearance remains in period and unchanged while the structure supporting would be completely renewed.

The long-term benefits of this option and substantial savings include:

- Ease of moving and drydocking the vessel at any future date
- Costs of replacement timbers would be limited to the house structure above the car deck
- Corrosion of fasteners under the waterline would be eliminated
- Potential catastrophic flooding and dockside capsizing of the vessel due to a sprung plank would be eliminated
- In house NPS resources would be able to maintain the structure above the main deck as they have been doing
- Environmental concerns for the copper bottom would be eliminated
- The adverse galvanic effect of the copper sheathing on the steel sidewheel framework would be eliminated
- After transferring the engine, boilers, auxiliary machinery to the new hull, the boiler room and other below deck spaces could be made accessible to persons with disabilities.
- Internal humidity inside the steel hull would be much lower than now, helping to preserve the historically-important machinery
- One or more structural cross-sections of the wood hull could be preserved in a protected shore side display of the original construction.
  Visitors would have much better access than they now do to study the unique heavy-timber construction methods.
- One side of the vessel could be rebuilt to show its original configuration, with coal-fired boilers, coal bunkers, coal-handling machinery, and railroad cars on the car deck.
- The engine and sidewheels could be operated alongside the pier, using compressed air.
- Some of the area below deck could be repurposed into workable space for NPS staff.

But, most importantly, the reoccurring costs associated with wood deteriorating and fasteners corroding with time would be drastically reduced and would result in a reduced and more manageable capital expense.

Section A.12 Supporting Photos

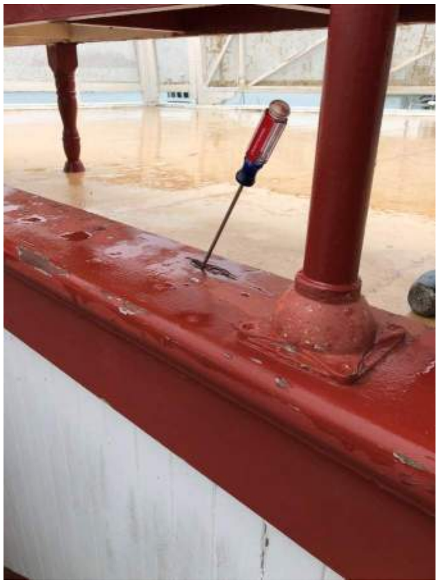

Photo 16: Rot in Railing

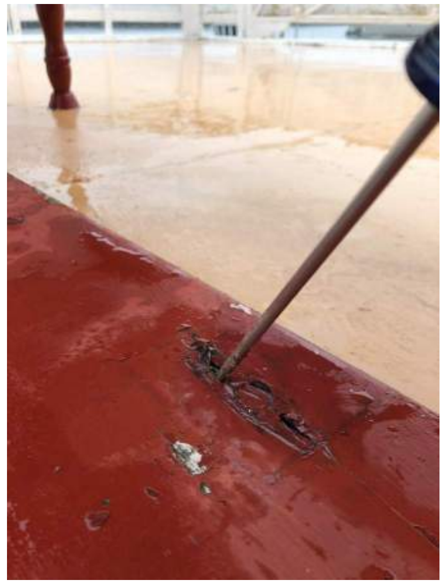

Photo 17: Close up of rot in railing

Photo 18: Hogging Strap Corrosion

Photo 19: Hogging Strap Corrosion

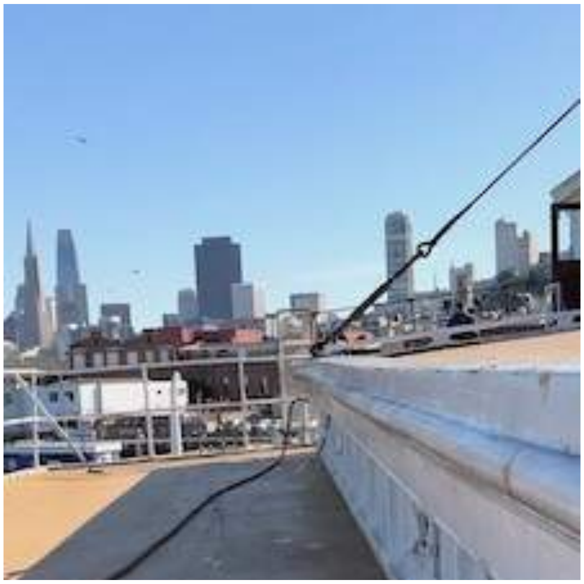

Photo 20: Guy Tension Deforming Roofline

Photo 21: Frame Bulkhead Connection

Photo 22: Rub Rail Rot

Photo 23:Rub Rail & Apron Rot

Photo 24: Frame Deformation Around Windows

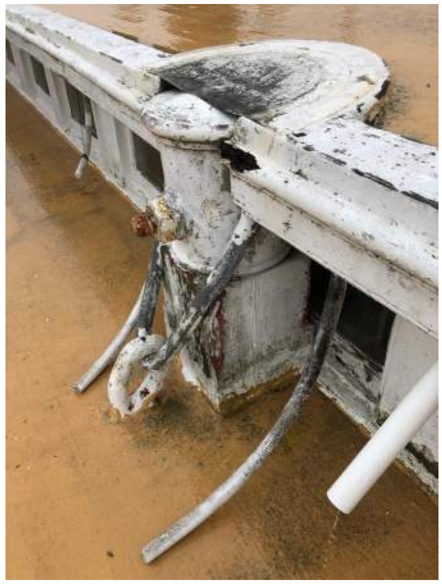

Photo 25: Covering Board Rot

Photo 26: Rot in Deck Window Transition

Photo 27: Rot in Sash and Window Support Structure

Section B. Hydrostatic Analysis of the Ferry Eureka

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Fayetteville, NY 13066
Brian@ThomasNavArch.com
617-653-5725
www.ThomasNavArch.com

24 Jan 2020

Marine Technical Services LLC
San Rafael, CA 94901

Subject: Hydrostatic Analysis of the Ferry EUREKA

Dear Mr. Guild,

At your request I have reviewed the information provided regarding the Ferry EUREKA and have analyzed the intact and damaged stability to the extent possible. Additionally, I have made a cursory review of longitudinal strength.

Information Provided:

1) Lines Drawings for the EUREKA, 5 Sheets, by Richard K Anderson, 1996
2) Deck Plans & Midship Section Drawing for the EUREKA, 2 Sheets, by Tri-Coastal Maine, 1990
3) Inboard Profile Drawing for the EUREKA, 1 Sheet, by Tri-Coastal Marine, 5/1990
4) Scanned Documents from the National Parks Service Archives containing:
    a. Weight Distribution Estimates, dated 1/6/1993
    b. Longitudinal Strength Calculations, dated 6/2/1993
    c. Section Modulus Calculations, undated
    d. Docking Stability Calculations, undated
    e. Incomplete inclining calculations, dated 2/2/1993
5) Freeboard survey results, by Tony Guild, dated 12/20/2019

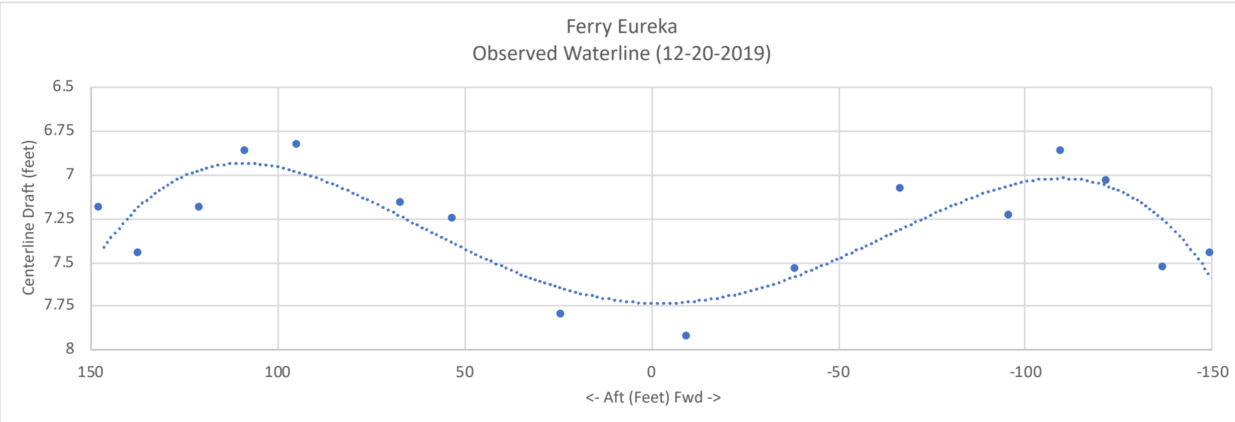
Work Performed:

A General Hydrostatics (GHS) model of the EUREKA was created based on the lines drawings. The lines are notably not molded and were taken to the outer face of the planking when the vessel was drydocked in 1993. As such, the GHS hull geometry represents the extreme hull dimensions and no allowance for planking thickness has been considered. Compartmentation and a wind profile were included in the model based on your survey and the drawings referenced above.

You provided a set of sixteen freeboards (port and starboard) measured from the EUREKA's rub rail and taken during your survey on December 20, 2019. Those freeboards were converted to centerline keel drafts and used to estimate the EUREKA's current afloat displacement. There are references to an inclining performed in the early 1990's, however it is unclear whether the calculations found in the National Parks Service (NPS) Archives are from planning prior to the actual stability test or actual results, the implied vertical center of gravity (VCG) in those calculations is approximately 17.26 ft. Based on the date on the calculations (2/2/1993), it is presumed that they date from before her drydocking and are not from an actual test. As a result, this analysis works from the 1922 inclining experiment calculated VCG of 18.02 ft as referenced in the docking calculations found in the NPS Archives. Using the estimate of the current displacement, the vessel's intact and damaged stability was assessed against the criteria in 46 CFR 170.170, 170.173 and a one compartment standard of subdivision.

Finally, the longitudinal strength calculations found in the NPS Archives were updated based on the new floating displacement and compared with the hull deflection observed during the freeboard survey. The weight distribution and section modulus data found in the NPS archives were not validated.

Results:
The surveyed freeboards were not measured to the precision required for a stability test per ASTM F1321, however with 16 survey points per side the results do provide a clear picture of hull deflection and a reasonably accurate estimate of the afloat waterline. A plot of the calculated drafts is provided in the figure below. (Note: the vertical scale has been reversed to show sag as down and more clearly represent the curvature of the vessel.) The waterline plot shows approximately a foot of sag amidships, but it also shows substantial sagging of the extreme forward and aft portions of the main deck cantilevered beyond the buoyant hull.



The draft curve was truncated to the buoyant hull envelope for entry into GHS and resulted in a displacement of approximately 1630 long tons and 11-1/4 inches of sag based on a least-squares fit of the draft data. (Full GHS output for these calculations is attached as Appendix A) This calculated displacement is approximately 180 long tons heavier than that reported in 1993. With a tons per inch of immersion (TPI) of 21 long tons per inch, it is possible that some portion of this discrepancy is due to freeboard measurement error, but it is unlikely that across 32 freeboard measurements (16 per side) that the overall data set is 9 inches off. Rather it is likely that the vessel gained weight over the past 25 years. To be conservative, the weight growth was considered to be centered 24 feet above baseline (well above the main deck) and distributed longitudinally over the full length of the deck house.

The intact stability analysis was focused on the suitability for a deadship tow. The results indicate that as she currently sits that she complies with the weather criteria in 46 CFR 170.170 for operation on Exposed Waters. However, the EUREKA only appears to meet the requirements of 46 CFR 170.173 for operation on Protected Waters, primarily due to her low downflooding angles through openings in the side shell for the paddle wheel shafts and main deck windows.

Damaged stability calculations presume watertight boundaries between compartments, which may be a poor assumption in practice. The results indicate that the EUREKA will remain afloat with the main deck above waterline when flooding the space between any two consecutive main transverse watertight bulkheads, with the important exception of the engine room. In the case of unrestricted flooding to the engine room, damaged stability calculations indicate that while the EUREKA would remain afloat, the free surface effects would cause the vessel to become unstable and capsize.

The longitudinal strength results mirror those found in the 1993 reports. The 1993 documents alternately indicate sagging still water bending moments of 6324 ton-ft and 6572 LT-ft. The GHS calculations indicate still water bending moments of 6830 LT-ft or a 4% increase over the 1993 results. This difference is largely attributable to the 180 long tons of increased weight and to a smaller extent, an increase in integration points in the longitudinal strength calculations themselves. Using the new still water bending moments, the resulting hull girder bending stresses were 400 psi in compress, and 313 psi in tension for the main deck and keel respectively. Douglas fir has a

wet modulus of rupture of 7500 psi and a modulus of elasticity of approximately 1.5×10^6 psi. This indicates that there is little chance of hull girder failures due to the strength of the timber alone, the fasteners and other structural connections are another matter and were not assessed in for this report. The calculated hull girder deflection based on the bending moments and modulus of elasticity is only approximately 1.5 inches, substantially less than the 1 foot of observed sag.

Conclusions:

The freeboard survey confirms visual observations about the overall hull girder deflection. The visible, and measurable, sagging of the cantilevered portions of the decks over the rudders is a potential concern as it indicates that the framing supporting those decks may no longer have an adequate structural connection to the rest of the hull. The approximate 1 foot of measured sag amidships is reasonable and not necessarily a cause for immediate concern. The discrepancy between the foot of observed sag and predicted 1.5 inches of sag (based on the bending moments) probably arises from a lack of structural rigidity. This is likely due to some combination of lack of holding power in the fastenings and changes in the structural properties of the hull timbers.

The stability calculations suggest that the EUREKA has adequate intact stability characteristics for a calm water tow to a repair facility. Damaged stability however is greater concern. Unrestricted flooding in the engine room would be catastrophic. As such, measures should be taken to monitor for signs of water ingress in all compartments and pumps should be pre-staged onboard the vessel during transit to address any flooding, should it occur. Additionally, efforts should be taken to seal the openings in the side shell in the vicinity of the shear clamps where the wheel shafts exit the hull.

If you have any questions regarding this analysis, please don't hesitate to contact me.

Sincerely,

Brian Thomas, P.E.

EUREKA ANALYSIS

CONDITION BASED ON 1993 DOCUMENTS

WEIGHT and DISPLACEMENT STATUS

Baseline draft: 6.637 @ Origin

Trim: Fwd 0.08 deg., Heel: zero

Part	SpGr	Weight(LT)	LCG	TCG	VCG	
WEIGHT		1,443.84	0.99f	0.00	18.02	
	SpGr	**Displ(LT)**	**LCB**	**TCB**	**VCB**	**RefHt**
HULL	1.025	1,443.94	1.01f	0.00	3.57	-6.64
Righting Arms:			0.00	0.00		

Distances in FEET.

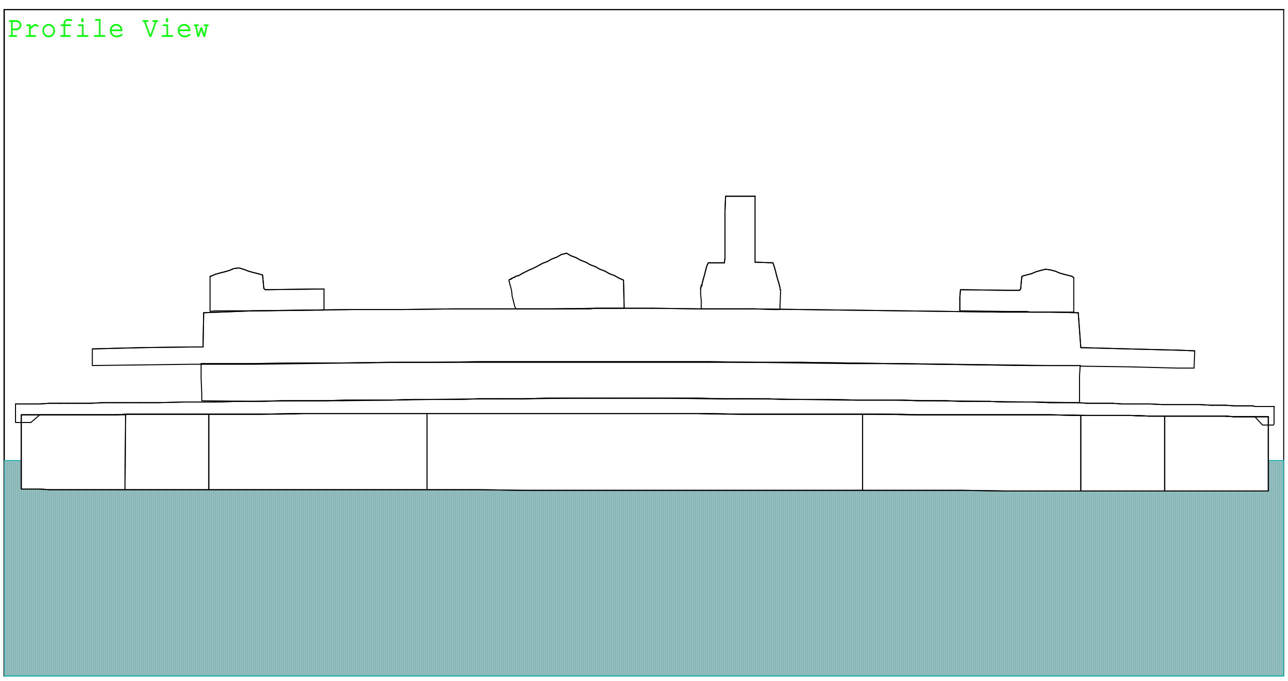
HYDROSTATIC PROPERTIES

Trim: Fwd 0.08 deg., No Heel, VCG = 18.02

LCF Draft	Displacement Weight(LT)	Buoyancy-Ctr. LCB	Buoyancy-Ctr. VCB	Weight/ Inch	LCF	Moment/ Deg trim	GML	GMT
6.638	1,443.94	1.01f	3.57	20.94	0.28f	18074	717.1	5.94

Distances in FEET. Specific Gravity = 1.025. Moment in Ft-LT.
Draft is from Baseline.

Condition Graphic - Draft: 6.64 @ 0.00 Trim: fwd 0.08 deg. Heel: zero



EUREKA ANALYSIS

FREEBOARD SURVEY RESULTS

DRAFTS used to establish Waterline and Deflection

Location	Given	Used	Error
122.23f	7.032	6.889	0.143
109.88f	6.862	7.025	-0.163
96.17f	7.238	7.159	0.079
66.89f	7.079	7.383	-0.304
38.82f	7.541	7.519	0.022
9.88f	7.922	7.579	0.343
23.93a	7.798	7.544	0.254
52.64a	7.251	7.426	-0.175
66.46a	7.166	7.341	-0.175
94.22a	6.830	7.113	-0.283
108.33a	6.870	6.968	-0.098
120.29a	7.187	6.830	0.357

Distances in FEET. Drafts from Baseline Deflection overall: 0.938 SAGGING

Deflection removed

WEIGHT and DISPLACEMENT STATUS
Baseline draft: 7.371 @ Origin
Trim: Fwd 0.02 deg., Heel: Port 0.39 deg.

Part	SpGr	Weight(LT)	LCG	TCG	VCG	RefHt
LIGHT SHIP		1,443.84	0.99f	0.00	18.02	
Weight Growth		185.58	5.75a	0.22p	24.00	
Total Weight --->		1,629.42	0.22f	0.03p	18.70	
	SpGr	Displ(LT)	LCB	TCB	VCB	RefHt
HULL	1.025	1,629.41	0.23f	0.13p	3.96	-7.37
Righting Arms:			0.00	0.00p		

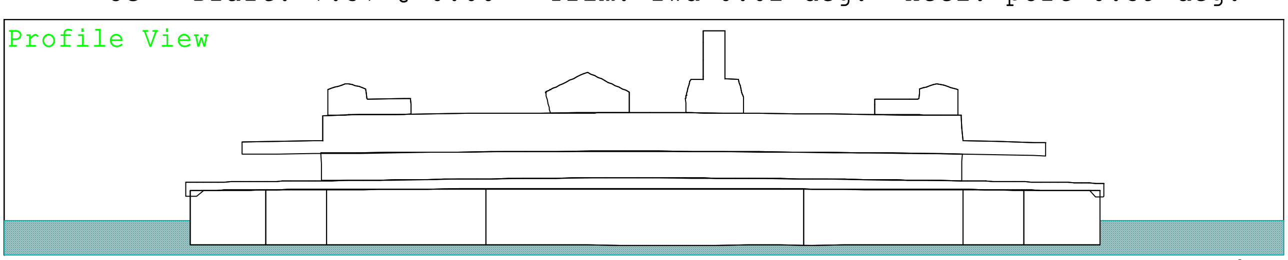
Distances in FEET.

HYDROSTATIC PROPERTIES
Trim: Fwd 0.02 deg., Heel: Port 0.39 deg., VCG = 18.70

LCF Draft	Displacement Weight(LT)	Buoyancy-Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ Deg trim	GML	GMT
7.371	1,629.41	0.23f	3.96	21.21	0.07f	18615	654.5	3.66

Distances in FEET. Specific Gravity = 1.025. Moment in Ft-LT.
Draft is from Baseline.

CG - Draft: 7.37 @ 0.00 Trim: fwd 0.02 deg. Heel: port 0.39 deg.



EUREKA ANALYSIS

Intact Stability

RIGHTING ARMS vs HEEL ANGLE

LCG = 0.22f TCG = 0.03p VCG = 18.70

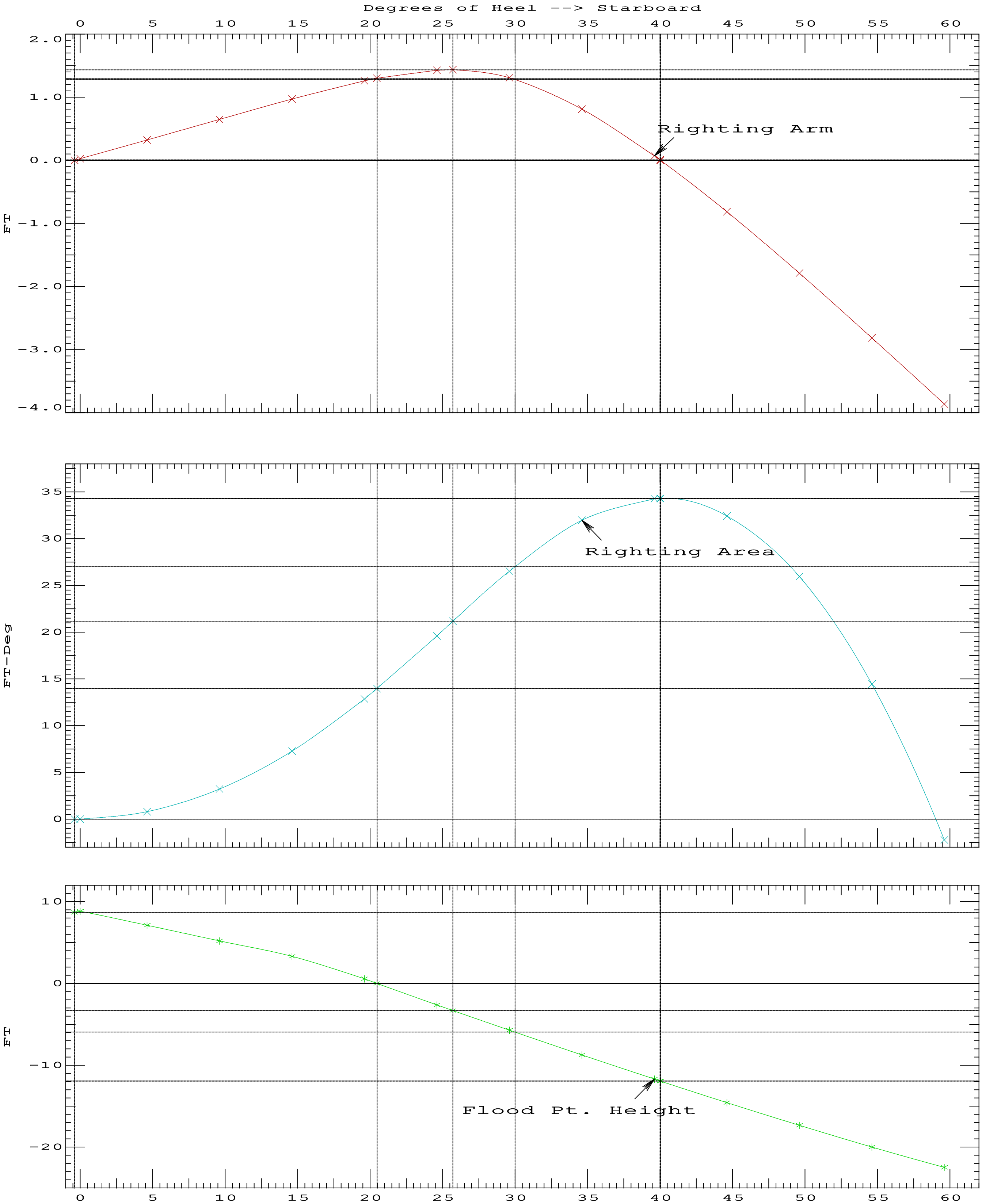
Origin Depth	Degrees of Trim	Heel	Displacement Weight(LT)	Righting Arms in Trim	in Heel	Area	Flood Pt Height
7.371	0.02f	0.39p	1,629.4	0.00	0.000	0.00	8.68(1)
7.371	0.02f	0.00	1,629.4	0.00	0.025	0.00	8.83(1)
7.339	0.02f	4.61s	1,629.4	0.00	0.321	0.80	7.11(1)
7.228	0.02f	9.61s	1,629.4	0.00	0.647	3.22	5.21(1)
7.030	0.02f	14.61s	1,629.4	0.00	0.971	7.27	3.31(1)
6.724	0.02f	19.61s	1,629.7	0.00	1.258	12.86	0.56(3)
6.655	0.02f	20.48s	1,629.2	0.00	1.301	13.96	0.00(3)
6.270	0.02f	24.61s	1,629.4	0.00	1.426	19.63	-2.63(3)
6.148	0.02f	25.71s	1,629.4	0.00	1.435	21.20	-3.32(3)
5.675	0.02f	29.61s	1,629.4	0.00	1.307	26.60	-5.71(3)
5.025	0.02f	34.61s	1,629.4	0.00	0.810	32.05	-8.73(3)
4.341	0.02f	39.61s	1,629.4	0.00	0.071	34.35	-11.70(3)
4.287	0.02f	40.00s	1,629.5	0.00	0.006	34.37	-11.92(3)
4.281	0.02f	40.04s	1,629.5	0.00	0.000	34.37	-11.95(3)
3.628	0.02f	44.61s	1,629.4	0.00	-0.815	32.55	-14.57(3)
2.892	0.02f	49.61s	1,629.4	0.00	-1.791	26.08	-17.34(3)
2.139	0.03f	54.61s	1,629.4	0.00	-2.816	14.59	-19.99(3)
1.375	0.03f	59.61s	1,629.4	0.00	-3.862	-2.10	-22.48(3)

Distances in FEET. Specific Gravity = 1.025. Area in Ft-Deg.

Note: No tank loads are present.

Critical Points		LCP	TCP	VCP
(1) Wheel Shaft Openings	FLOOD	0.00	21.17	16.20
(3) Main Deck Windows -F	FLOOD	18.50f	36.66	20.80

LIM 46CFR170.173 PP ROUTE CRITERION		Min/Max		Attained	
(1) Angle from abs 0 deg to RAzero	>	25.00	deg	40.04	P
(2) Angle from abs 0 deg to Flood	>	15.00	deg	20.48	P
(3) Area from abs 0 deg to abs 40 or MaxRA	>	10.00	Ft-deg	21.20	P
(4) Area from abs 0 deg to abs 40 or Flood	>	10.00	Ft-deg	13.96	P


Degrees of Heel --> Starboard
0
5
10
15
20
25
30
35
40
45
50
55
60
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
FT
Righting Arm
35
30
25
20
15
10
5
0
FT-Deg
Righting Area
10
0
-10
-20
FT
Flood Pt. Height

GM required according to CFR 170.170 Weather Criterion

Freeboard: 8.959
Freeboard remaining after half of it immersed: 4.480
Heel at freeboard 4.480 is 13.10 degrees (constant-displacement rotation)
Lesser of this and 14 degrees: 13.10

Heeling moment (PAH): 925.10   Displacement (D): 1629.42
P: 0.00540   A: 8193.470   H: 20.909

(PAH) / (D x tan(13.10)) = Required GM: 2.440

Current VCG: 18.701   Current GM: 3.664

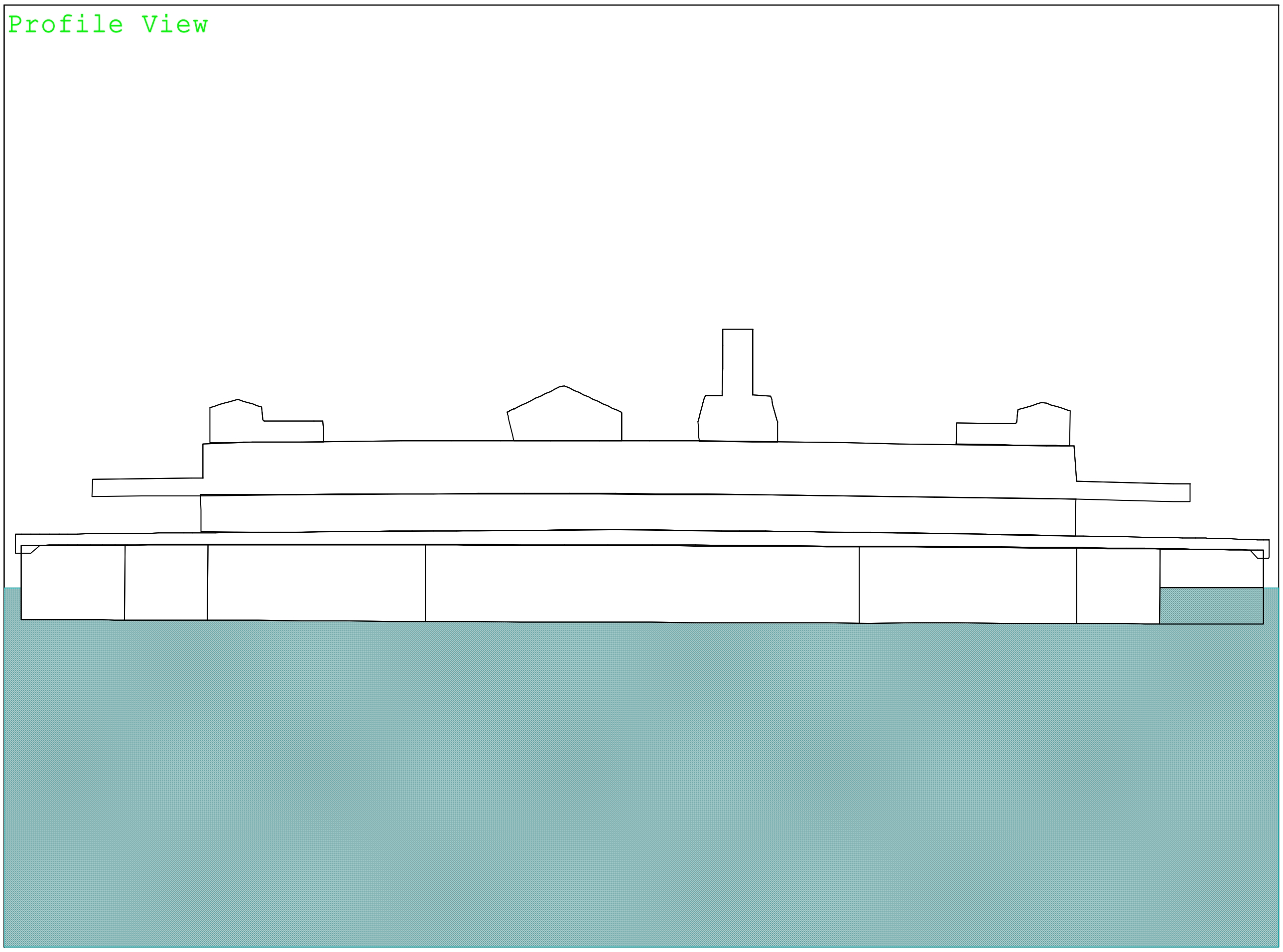
GM Required = 2.440	Actual GM = 3.664

Damage Case 1 -- Forepeak Flooded

FREEBOARD STATUS

Baseline draft: 7.485 @ Origin
Trim: Fwd 0.21 deg., Heel: Port 0.39 deg.
Least freeboard is 8.38 Ft located at 135.68f
Least extra freeboard (to margin line) is 8.38 Ft located at 135.68f

CG - Draft: 7.49 @ 0.00 Trim: fwd 0.21 deg. Heel: port 0.39 deg.

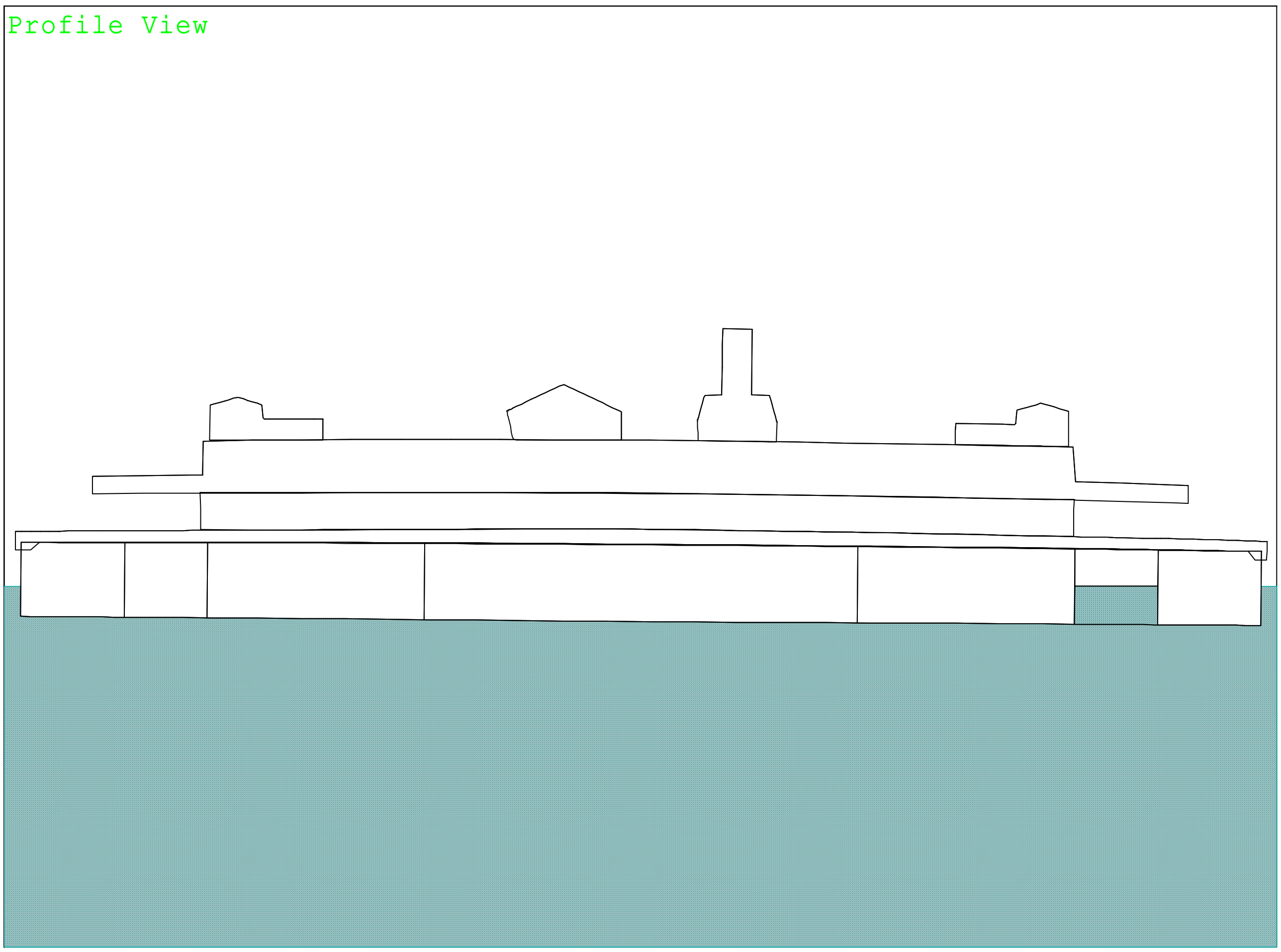


Damage Case 2 -- Hold #2 Flooded

FREEBOARD STATUS

Baseline draft: 7.650 @ Origin
Trim: Fwd 0.42 deg., Heel: Port 0.42 deg.
Least freeboard is 7.72 Ft located at 137.05f
Least extra freeboard (to margin line) is 7.72 Ft located at 137.05f

CG - Draft: 7.65 @ 0.00 Trim: fwd 0.42 deg. Heel: port 0.42 deg.



EUREKA ANALYSIS

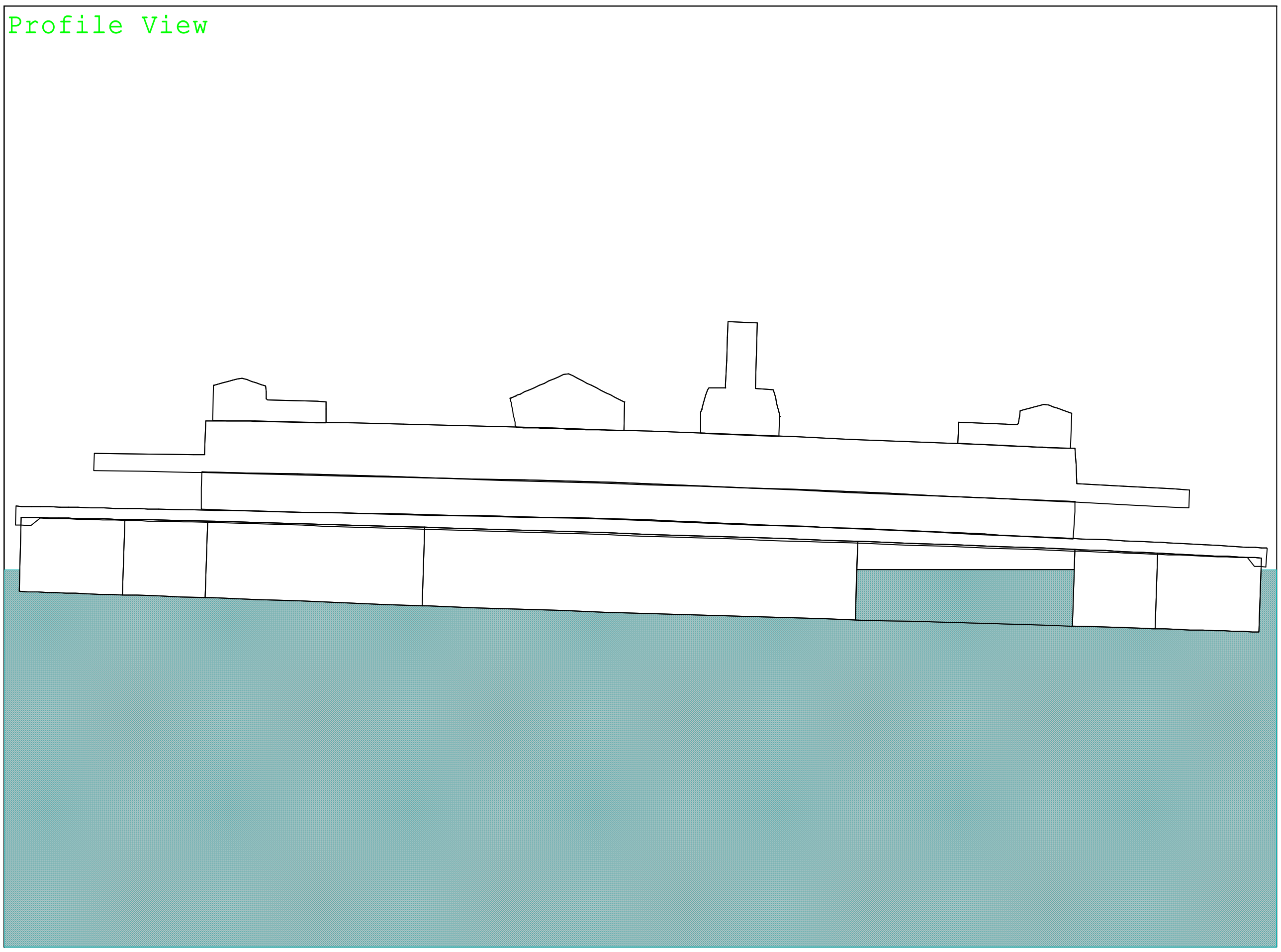
Damaged Stability

Damage Case 3 -- Hold #3 Flooded

FREEBOARD STATUS

Baseline draft: 9.306 @ Origin
Trim: Fwd 1.88 deg., Heel: Port 1.07 deg.
Least freeboard is 2.56 Ft located at 137.05f
Least extra freeboard (to margin line) is 2.56 Ft located at 137.05f

CG - Draft: 9.31 @ 0.00 Trim: fwd 1.88 deg. Heel: port 1.07 deg.

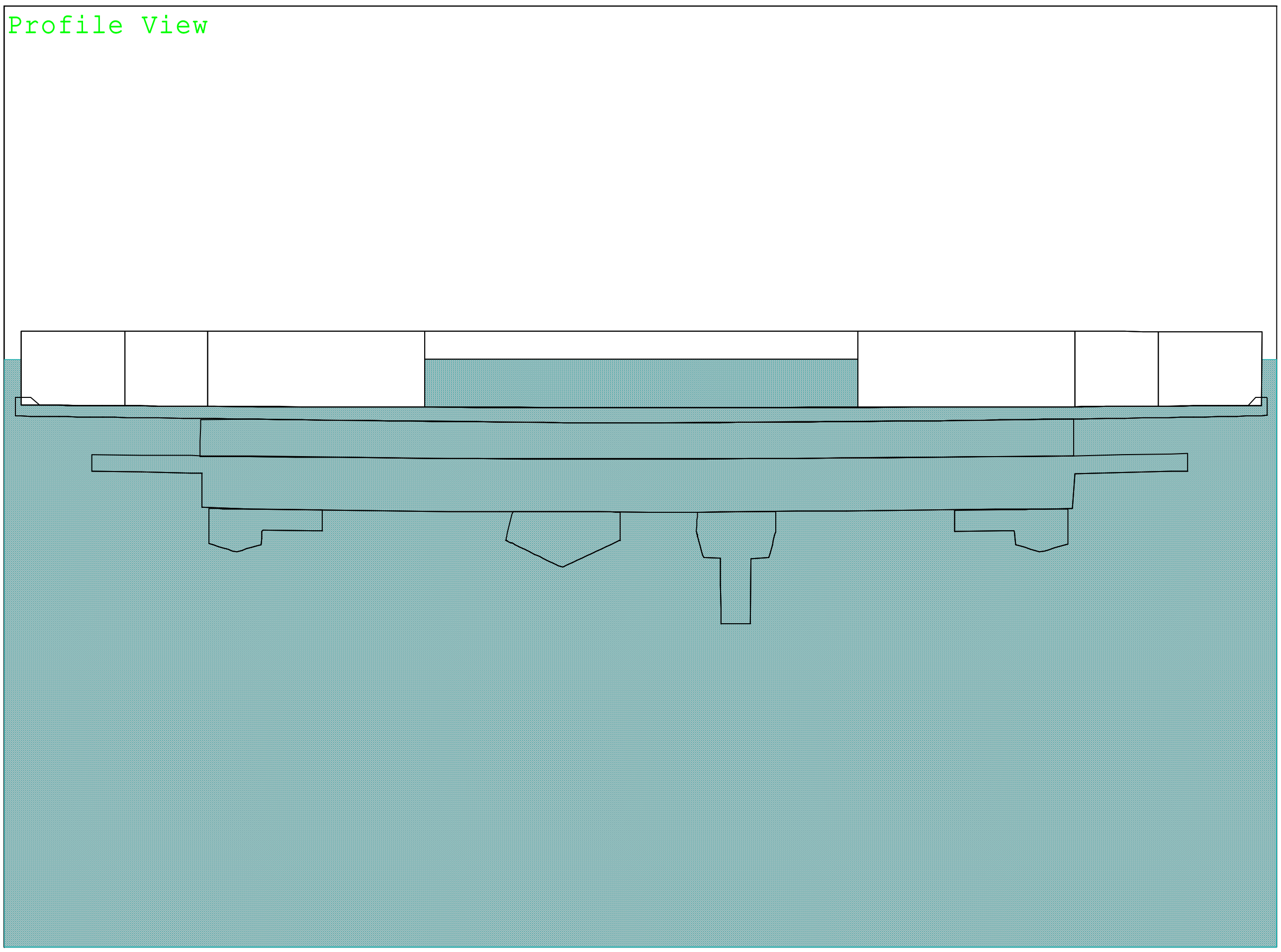


Damage Case 4 -- Engine Room Flooded

FREEBOARD STATUS

Origin Depth: -6.098
Trim: Fwd 0.02 deg., Heel: Port 179.90 deg.
Least freeboard is -10.74 Ft located at 11.71f
Least extra freeboard (to margin line) is -10.74 Ft located at 11.71f

CG - Origin Depth: -6.098 Trim: fwd 0.02 deg. Heel: port 179.90 deg.



EUREKA ANALYSIS

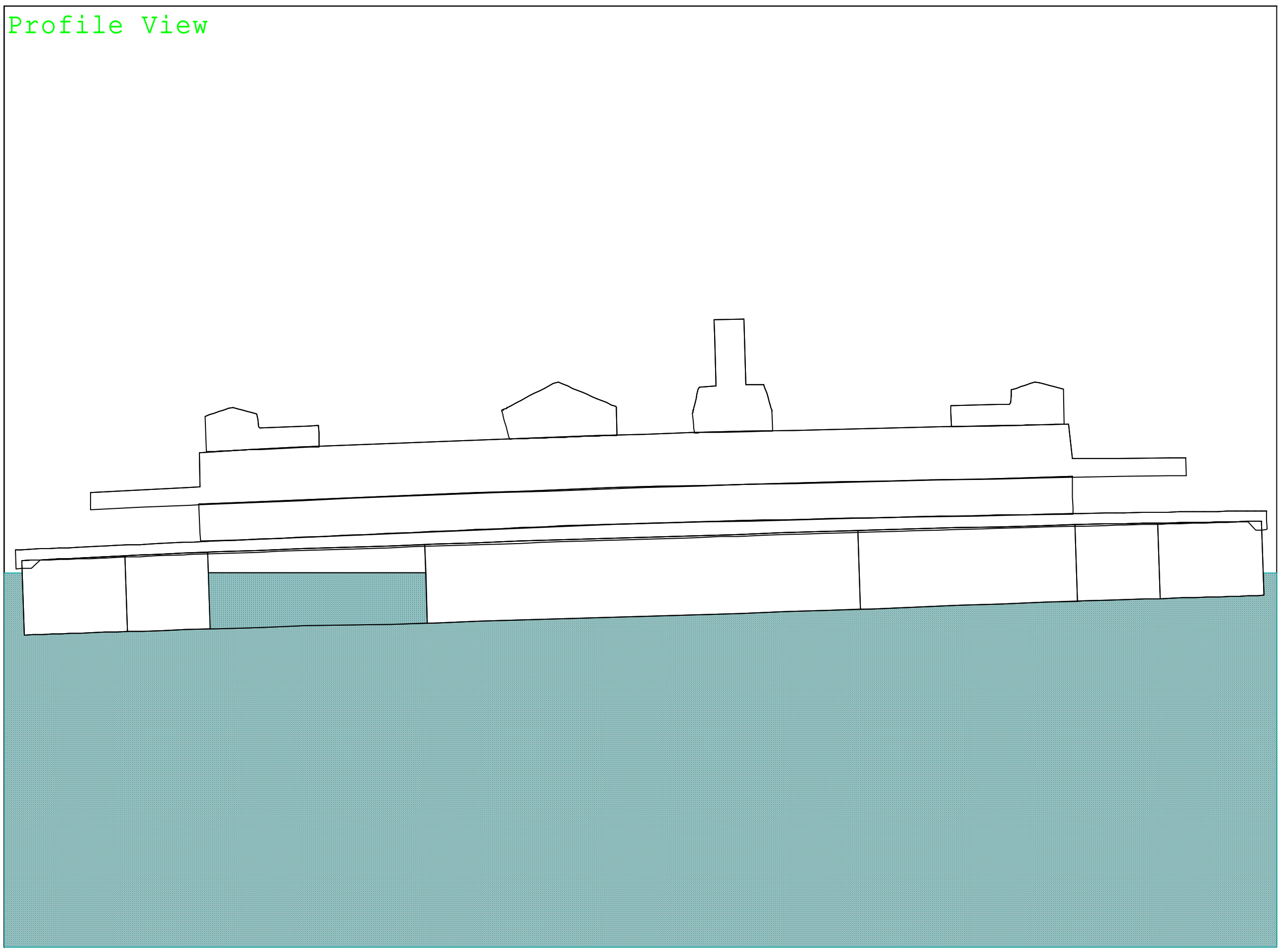
Damaged Stability

Damage Case 5 -- Hold #4 Flooded

FREEBOARD STATUS

Baseline draft: 9.296 @ Origin
Trim: Aft 1.83 deg., Heel: Port 1.07 deg.
Least freeboard is 2.69 Ft located at 137.04a
Least extra freeboard (to margin line) is 2.69 Ft located at 137.04a

CG - Draft: 9.30 @ 0.00 Trim: aft 1.83 deg. Heel: port 1.07 deg.



EUREKA ANALYSIS

Damaged Stability

Damage Case 6 -- Hold #5 Flooded

FREEBOARD STATUS

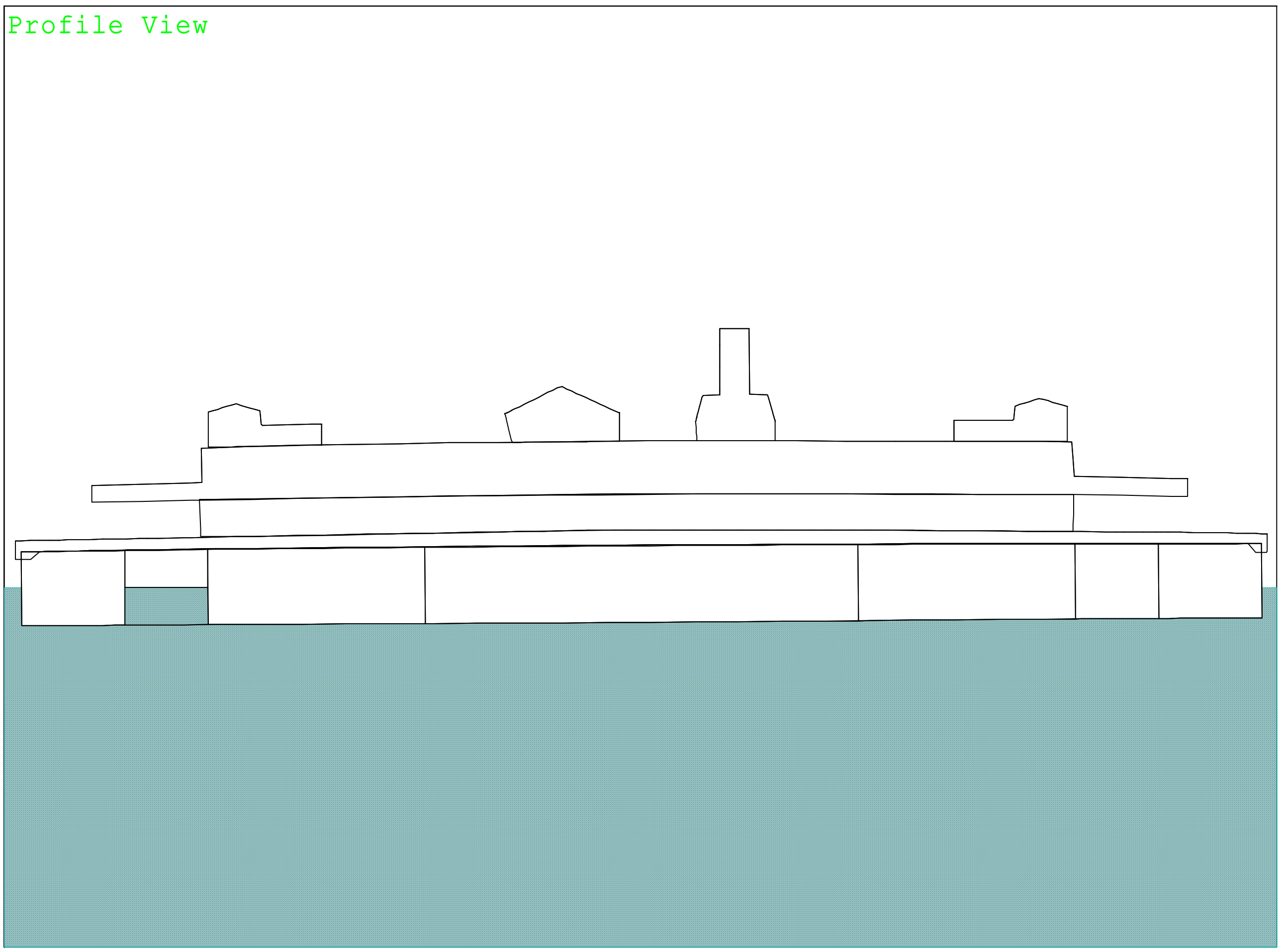
Baseline draft: 7.647 @ Origin

Trim: Aft 0.38 deg., Heel: Port 0.42 deg.

Least freeboard is 7.82 Ft located at 137.04a

Least extra freeboard (to margin line) is 7.82 Ft located at 137.04a

CG - Draft: 7.65 @ 0.00 Trim: aft 0.38 deg. Heel: port 0.42 deg.



EUREKA ANALYSIS

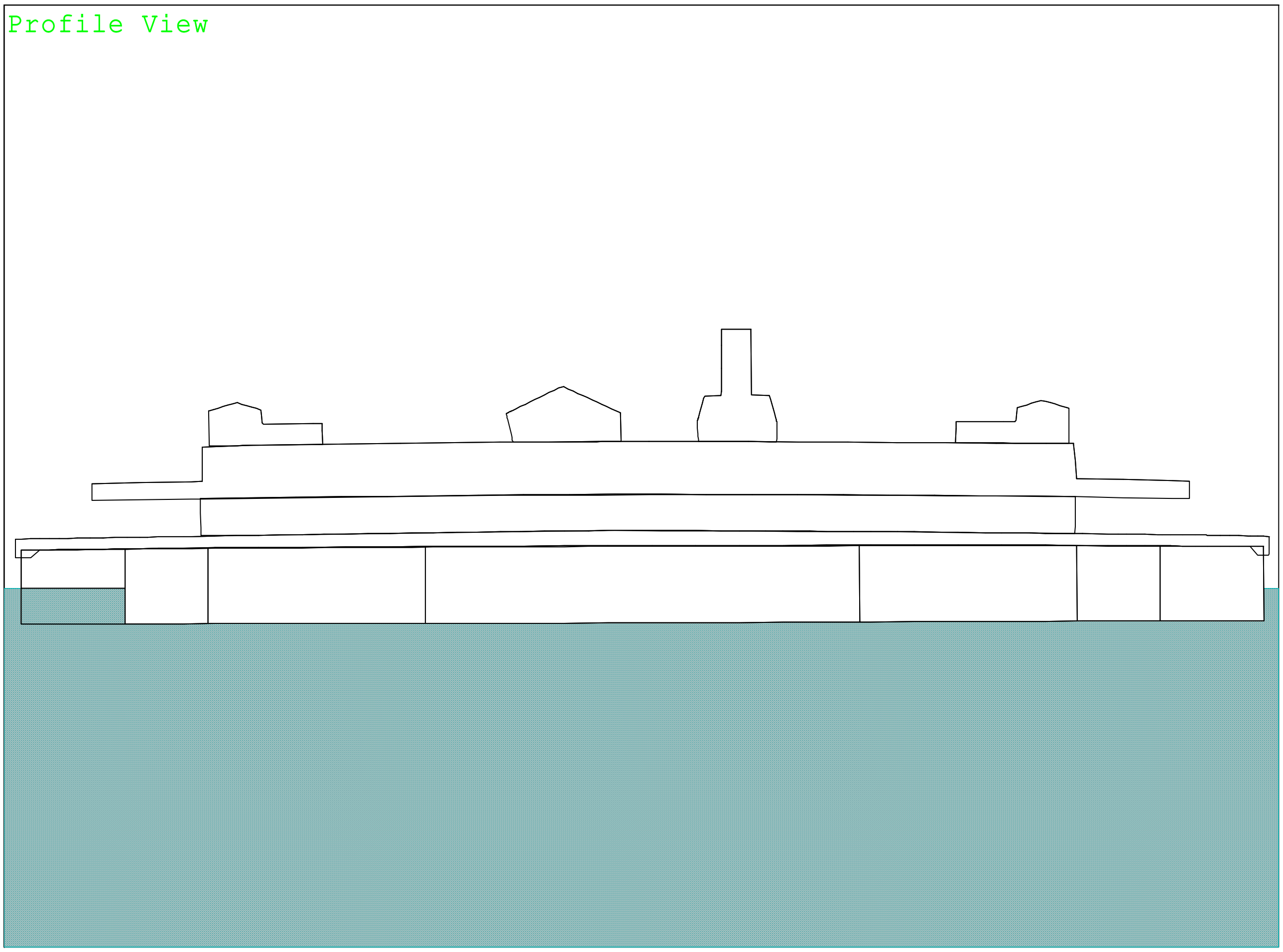
Damaged Stability

Damage Case 7 -- Aftpeak Flooded

FREEBOARD STATUS

Baseline draft: 7.483 @ Origin
Trim: Aft 0.17 deg., Heel: Port 0.39 deg.
Least freeboard is 8.48 Ft located at 132.91a
Least extra freeboard (to margin line) is 8.48 Ft located at 132.91a

CG - Draft: 7.48 @ 0.00 Trim: aft 0.17 deg. Heel: port 0.39 deg.



EUREKA ANALYSIS

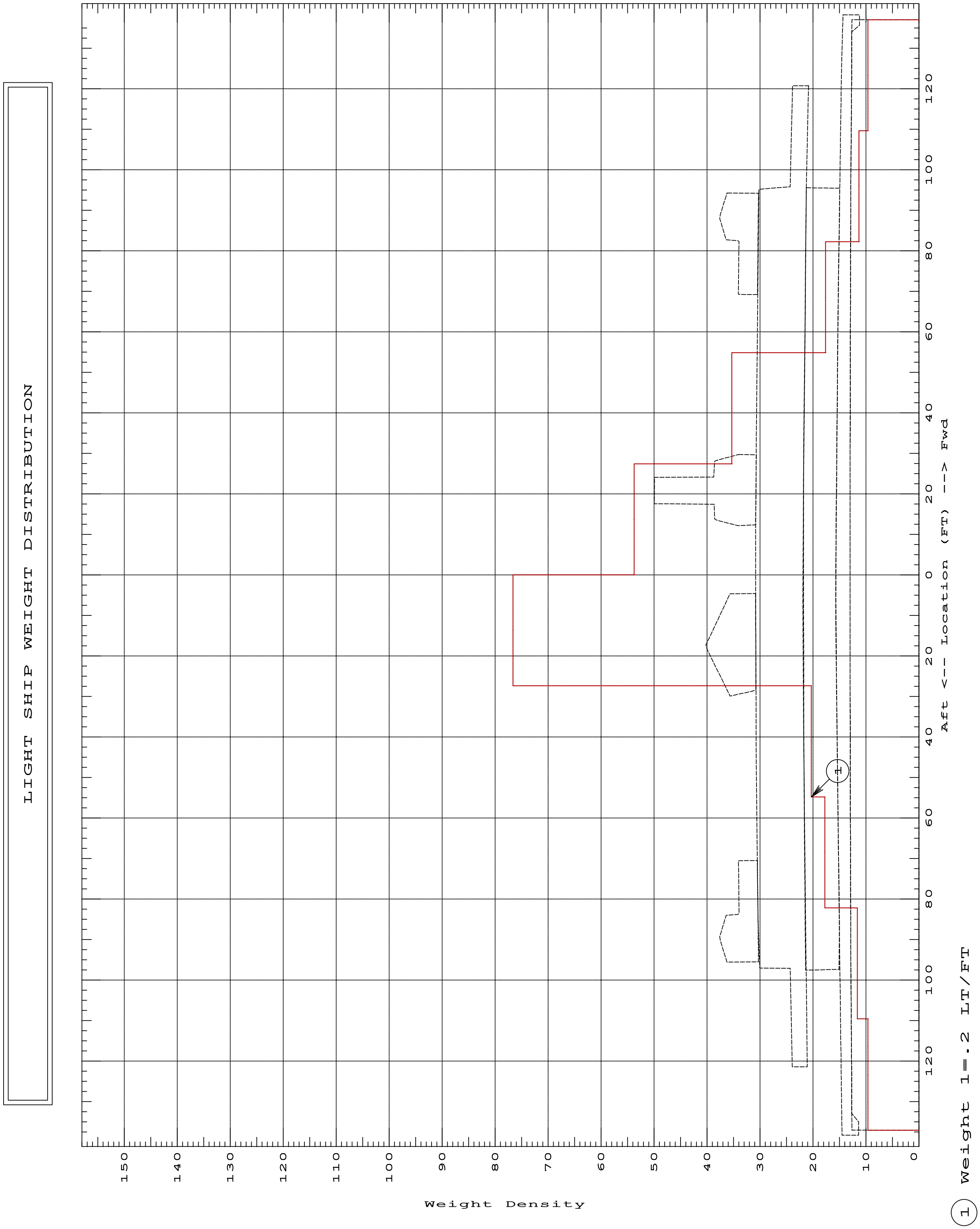
LONGITUDINAL STRENGTH

LIGHT SHIP WEIGHT DISTRIBUTION

LOCATION Ft	WEIGHT LT/Ft
137.00f	0.00
137.00f	1.92
123.30f	1.92
109.60f	1.92
109.60f	2.26
95.90f	2.26
82.20f	2.26
82.20f	3.52
68.50f	3.52
54.80f	3.52
54.80f	7.06
41.10f	7.06
27.40f	7.06
27.40f	10.75
13.70f	10.75
0.00	10.75
0.00	15.32
13.70a	15.32
27.40a	15.32
27.40a	4.06
41.10a	4.06
54.80a	4.06
54.80a	3.55
68.50a	3.55
82.20a	3.55
82.20a	2.32
95.90a	2.32
109.60a	2.32
109.60a	1.92
116.48a	1.92
123.35a	1.92
130.23a	1.92
137.10a	1.92
137.10a	0.00

EUREKA ANALYSIS

LONGITUDINAL STRENGTH



LONGITUDINAL STRENGTH

LOCATION Ft	WEIGHT LT/Ft	BUOYANCY LT/Ft	SHEAR LT	MOMENT LT-Ft
137.05f	0.00	0.00	0.0	0.0
137.00f	1.92	0.23	0.0	0.0
133.61f	1.92	0.50	-5.3	9.3
131.54f	1.92	0.66	-8.1	23.2
129.48f	1.92	0.83	-10.5	42.5
127.41f	1.92	1.00	-12.6	66.5
124.66f	1.92	1.24	-14.8	104.5
121.90f	1.92	1.50	-16.3	147.6
119.15f	1.92	1.78	-17.1	193.9
116.39f	1.92	2.09	-17.1	241.3
113.64f	1.92	2.40	-16.2	287.5
110.88f	1.92	2.72	-14.5	330.0
109.60f	2.26	2.88	-13.3	347.9
106.75f	2.26	3.21	-11.1	383.0
102.62f	2.26	3.70	-6.1	419.5
100.00f	2.26	4.02	-1.9	430.3
100.00f	3.03	4.02	-1.9	430.3
97.11f	3.03	4.36	1.4	431.4
88.85f	3.04	5.32	16.3	364.0
82.20f	3.06	6.01	33.6	200.9
82.20f	4.32	6.01	33.6	200.9
79.21f	4.32	6.32	39.2	92.2
69.56f	4.34	7.12	62.2	-390.0
59.92f	4.36	7.71	91.7	-1,127.1
54.80f	4.36	7.91	109.4	-1,641.7
54.80f	7.90	7.91	109.4	-1,641.7
50.28f	7.91	8.08	109.8	-2,136.8
40.64f	7.92	8.29	112.5	-3,206.7
31.00f	7.94	8.42	116.6	-4,309.6
27.40f	7.94	8.46	118.4	-4,732.1
27.40f	11.64	8.46	118.4	-4,732.1
21.36f	11.64	8.52	99.3	-5,389.6
11.71f	11.66	8.57	69.3	-6,202.2
2.07f	11.68	8.59	39.6	-6,727.0
0.00	11.68	8.59	33.2	-6,802.3
0.00	16.25	8.59	33.2	-6,802.3
7.57a	16.26	8.58	-24.9	-6,833.7
17.21a	16.28	8.53	-99.2	-6,235.6
26.85a	16.29	8.45	-174.4	-4,917.1
27.40a	5.03	8.44	-178.7	-4,820.2
36.49a	5.05	8.32	-148.3	-3,334.1
46.13a	5.06	8.15	-117.6	-2,053.4
54.80a	5.08	7.88	-92.1	-1,146.3
54.80a	4.56	7.88	-92.1	-1,146.3
65.42a	4.58	7.35	-59.6	-346.0
75.06a	4.60	6.63	-36.5	111.9
82.20a	4.61	5.95	-24.4	326.5
82.20a	3.38	5.95	-24.4	326.5

continued next page

EUREKA ANALYSIS

LONGITUDINAL STRENGTH

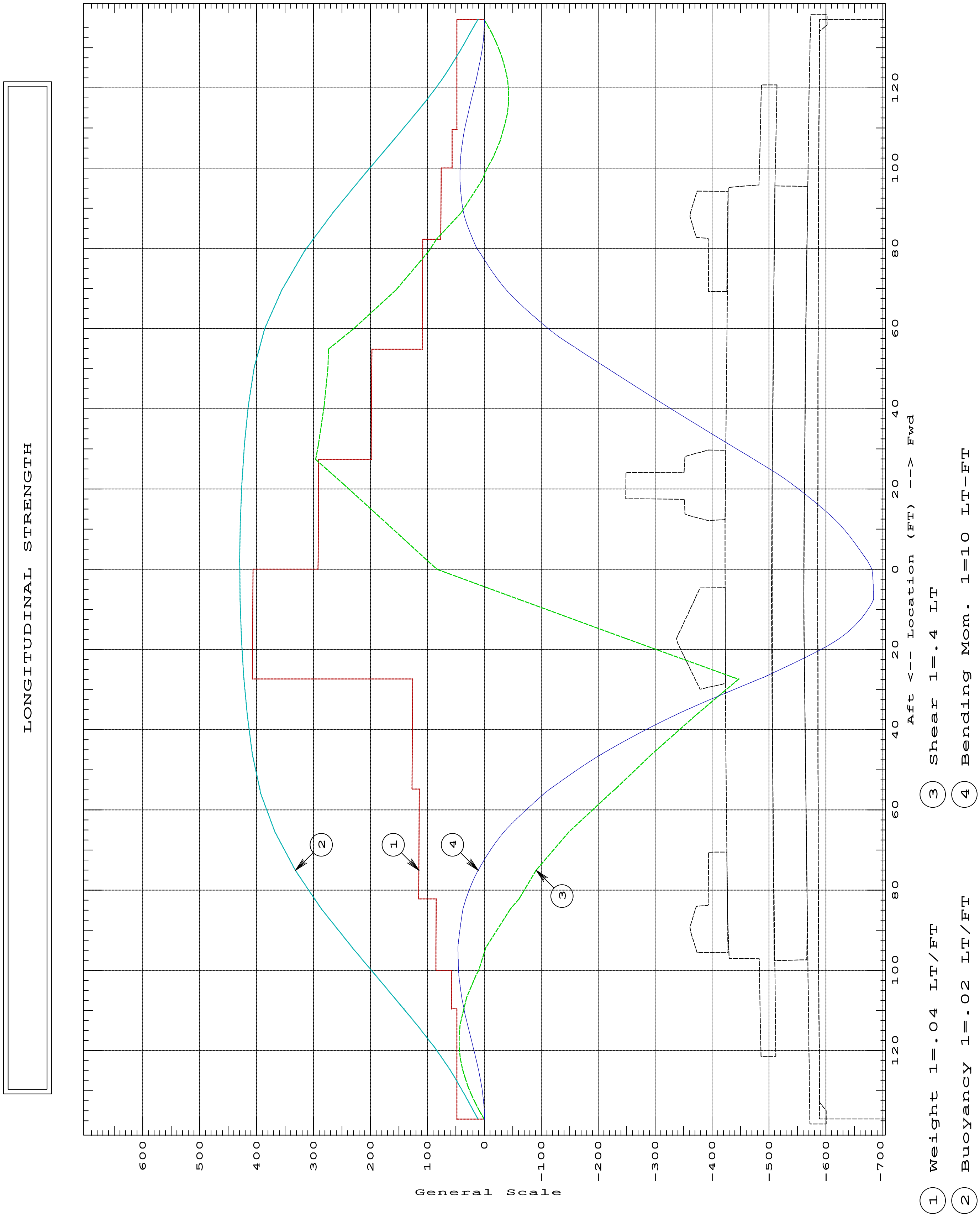
LOCATION Ft	WEIGHT LT/Ft	BUOYANCY LT/Ft	SHEAR LT	MOMENT LT-Ft
84.70a	3.38	5.71	-18.3	379.8
94.34a	3.40	4.63	-1.1	464.8
100.00a	3.41	3.96	4.0	455.1
100.00a	2.32	3.96	4.0	455.1
106.74a	2.32	3.16	12.3	397.4
109.60a	2.32	2.83	14.3	359.2
109.60a	1.92	2.83	14.3	359.2
113.62a	1.92	2.36	17.0	295.7
116.38a	1.92	2.05	17.7	247.8
119.13a	1.92	1.75	17.7	199.0
121.89a	1.92	1.47	16.8	151.4
124.64a	1.92	1.22	15.2	107.2
126.71a	1.92	1.04	13.6	77.5
128.77a	1.92	0.87	11.5	51.6
130.84a	1.92	0.70	9.2	30.2
132.91a	1.92	0.54	6.5	14.0
134.97a	1.92	0.38	3.5	3.7
137.04a	1.92	0.22	0.1	-0.0
137.10a	0.00		0.0	-0.0

S U M M A R Y

Largest Shear:	-178.7 LT	at	27.40a
Largest Bending Moment:	-6,834 LT-Ft	at	7.57a (Sagging)

EUREKA ANALYSIS

LONGITUDINAL STRENGTH



EUREKA ANALYSIS

LONGITUDINAL STRENGTH

Resulting Deck Stress
LONGITUDINAL STRENGTH SUMMARY

```
 Largest Shear:       -400.3 KP      at   27.40a
Largest Stress:       -0.425 KP/SqIn at    7.57a (Compression)
```

Resulting Keel Stress
LONGITUDINAL STRENGTH SUMMARY

```
 Largest Shear:       -400.3 KP      at   27.40a
Largest Stress:        0.313 KP/SqIn at    7.57a (Tension)
```

Predicted Deflection
Modulus of Elasticity 1.5E6 psi
LONGITUDINAL STRENGTH SUMMARY

```
         Largest Shear:       -398.5 KP      at   27.40a
Largest Bending Moment:      -15,066 KP-Ft   at    7.57a (Sagging)
    Largest Deflection:       -1.435 In      at    0.00  (Sag)
```

(2007). In U. D. Agriculture, *The Encyclopida of Wood* (pp. 13-4). Madison: Skyhorse Publishing.

Baker, A. J. (1980). Corrosion of Metal in Wood. *American Society for Testing and Materials*.

Caltrans. (2020, January 9). *Bay Bridge History*. Retrieved from The San Francisco-Oakland Bay Bridge Seismic Safety Projects: https://www.baybridgeinfo.org/history

Davis, A. (1993, July/August). Understanding the lonitudinal deformation of wooden ships. *Woodenboat*, pp. 70 - 77.

Department of the Navy. (1957). *Wood: A Manual for its Use as a Shipbuilding Material Vol I.* Kingston, MA: Teaparty Books.

Don Birkholz, Jr. Tri-Coastal Marine. (1990). *Ferry Steamer Eureka Historic Structure Report 1990.* San Francisco.

Eureka Fire Supression System Contract. (1997, February). *Contract 1443-CX-8520-92-003 & 1443-CX-8520-96-068*. San Francisco, CA, USA: San Francisco Maritime National Historic Park National Park Service.

Harlan, G. H., & Fisher, Jr., C. (1951). *Of Walking Beams and Paddle Wheels.* Salina: El Camino Press.

Jagels, R. (1992, March/Apr). When Decay is Not Rot. *Wooden Boat*, pp. 112-113.

National Park Service. (2019, May 31). Scope of Work. *Title I - Scope and Cost validation NHL Ferryboat Eureka - Critical Syatems SAFR-PMIS229380*. San Francisco, CA, USA.

San Francisco Maritime National Historical Park. (2016, January 27). *Eureka History*. Retrieved from National Park Service: https://www.nps.gov/safr/learn/historyculture/eureka-history.htm

San Francisco Maritime National Historical Park Internal Memorandum. (1993). Notes on Eureka, End of year 1993. *Internal Memorandum*. CA: NPS.

Slaymaker, S. E. (1992, March/April). Repairing an Iron0sick Bilge. *WoodenBoat*, pp. 42-45.

State of California. (2020, February 16). *§ 6190. Copper-Based Antifouling Paints and Coatings.* Retrieved from California Code of Regulations (Title 3. Food and Agriculture) Division 6. Pesticides and Pest Control Operations: https://www.cdpr.ca.gov/docs/legbills/calcode/020103.htm#a6190

USCG. (1995). *Guidance in Inspection, Repair and Maintenance of Wooden Hulls.* Washington, DC: United States Coast Guard.

Zelinka, S. L., & Kirker, G. T. (2018). *Assessment of Fastener Corrosion and Salt Damage in the Bilge of the Eureka.* Madison: United States Department of Agriculture.

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[i] Don Birkholz, Jr "Ferry Steamer Eureka Historic Structure Report 1990" Tri-Coastal Marine, Inc., 1990

[ii] United State Coast Guard; Navigation and Inspection Circular No.7-95: Guidance on Inspection, Repair and Maintenance of Wooden Hulls: 1995, Enclosure 1 Glossary, pp. G-1 - G10

[iii] United States Department of Interior Memorandum dated December 21, 1993 to Joel Dancer Project Superintendent SFD from Mike Bell, COR, NPS

[iv] United States Department of Interior Memorandum dated April 12, 1994 to Karen Giles Contracting Specialist from Mike Bell, Project Manager

[v] Anamet Materials Engineering & Laboratory Testing Report No. 5005.7872 dated February 6, 2020

[vi] Department of the Navy Bureau of Ships: *"Wood: A Manual for its use as a Shipbuilding Material"* Vol 1., 1957.

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Appendix E

2022 Supplement Structural Condition of the Ferry *Eureka*

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Ferry Steamer Eureka

Supplemental Structural Condition of the Ferry Eureka
(Revision 1)

Jan *7, 2022*

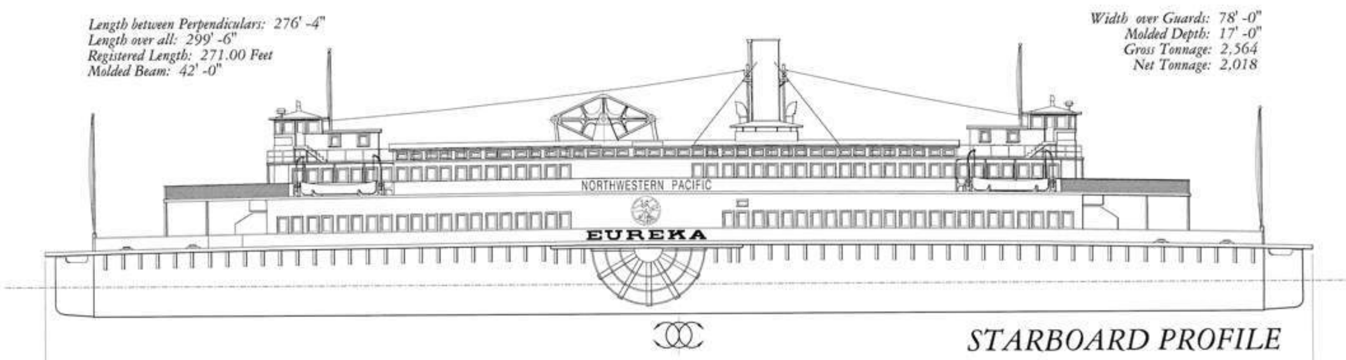

Photo 1 Drawing of Eureka
Drawing of Eureka by Richard K Anderson, Jr., 1996

By: Anthony Guild
Editors: Ed McClave & Brian Thomas
Drafting: Tony Guild

Background

In late 2019, Maritime Technical Services contracted with Robert Pecca & Associates / Mott McDonald under a task order, titled: Title I - Scope and Cost Validation – NHL Ferryboat Eureka Project-Critical Systems SAFR-PMIS 229380, to provide a report documenting the condition of the Ferryboat *Eureka.* That report was completed in 2020. In late 2021, Maritime Technical Services was again contracted, this time to assist in documenting any significant changes in the *Eureka's* condition since the surveys that were the basis of the 2020 report.

Abstract

The historic American ship *Eureka* at 299 feet long, 80 feet wide and weighing over 3.5 million pounds is currently considered the largest floating wood structure in the world. A National Historic Landmark and a contributing feature to the San Francisco National Historical Park, the vessel is permanently moored at the historic Hyde Street Pier in San Francisco, California.

This report provides an updated analysis on the current condition of the *Eureka* as the vessel sits in the water as of December 2021 and as compared to the conditions observed in late 2019 and early 2020. The 2020 report should be consulted while reviewing this document. Importantly, this report makes no recommendations regarding the different paths to either stabilize, preserve, or restore the *Eureka*. Those recommendations are part of the broader task and are included in the Ferryboat Eureka Historic Structure Report Parts I and II – PMIS 227029, Task Order No. 140P8521F0044

As I did in 2020, this supplementary report reflects the *Eureka's* condition observed following a physical examination of the vessel. Specific emphasis was again placed on the structural condition of the hull, deck, and superstructure including framing, and both internal and external planking. During this examination, no evaluation was completed regarding the vessel's electrical systems, fire detection system, fire suppression systems, or regarding the condition of any of the various coating systems.

The 2020 report concluded the following, which has not fundamentally changed.

"*Based on my direct observation, the Eureka has aged dramatically over the 30 years since her last structural survey and dry docking. The advanced decay of her timbers and corrosion of her fasteners require immediate and extensive repair for the vessel to remain in her current service.*"

Importantly, over the last twelve months the *Eureka* has deteriorated further and faster than expected. Defects that were previously identified have in some cases become immediate threats to the safety of the vessel.

Report of Condition

On October 22, 2021 and December 15, 2021, Anthony Guild of Maritime Technical Services (MTS) completed a waterborne survey of the *Eureka* with the vessel moored in San Francisco, California. This report is the result of those vessel visits and concentrates on two key areas. First, the vessel's sponson and outer rub rail and second, the vessel's internal structural fastenings. The main reason for this was due to deterioration in at the port bow adjacent to the mooring dolphin that have taken the vessel out of service. Additionally, the current survey revealed excessive corrosion in several important fasteners that were well inside the watertight envelope of the hull and in the structure.

For the purpose of this report, the bow of the vessel is considered the end of the vessel facing the city of San Francisco.

Importantly, during my first visit to the vessel, Park Service personnel were in the process of shifting the mooring arrangements aft and had removed the gangway from the vessel. These changes were being made following a weather event that, coupled with the advanced defects in the sponson at the bow resulted in a portion of the outer sponson rub rail and deck surrounding that area failing. (See Photo 2 and Photo 3)

Sponson Deck and Rub Rail

The 2020 report documented the structural arrangement of this portion of vessel:

"The sponson deck, the portion of the main deck which extends outboard of the hull, is supported by the main deck beams and, at the fore and aft ends, by a series of radiating beams or "fan timbers". The outboard portions of the deck beams are supported by hanging knees and 6" x 6" diagonal braces, in alternating sequence. A "rub-rail" comprised of several heavy timbers measuring 23" x 30" x 45', along the outboard edge of each paddle box. These support the superstructure in way of the paddle wheels."

Photo 2

Image of the damage to the main deck in way of the dolphin impact point (2021)

Photo 3

Image of the extensive decay (rot) on the Sponson structure (2021)

Photo 4

Image of Sponson from the waterline looking up at the impact point of the port SF Side bow (2021)

The damage to the port side of the vessel at the bow is now severe. This portion of the vessel has deteriorated to the point that the structure can no longer withstand the constant impacts with the mooring dolphin. (See Photo 2, Photo 3, Photo 4 and Figure 1.) Noticeable structural degradation can be seen when comparing the photographs taken in 2020 (Photo 5) versus the photographs taken in 2021 (Photo 4).

The loss of structural integrity due to advanced decay in the rub rail and deck beam timbers is the underlying cause of the damage visible in the photographs. The deteriorated timbers have no remaining strength and were no longer capable of withstanding the vessel's impact with the mooring dolphin (reportedly more severe during the recent inclement weather).

As noted in the 2020 report, decay, or rot as it is commonly referred to, is a result of the freshwater intrusion into the seams between timbers and is a natural phenomenon in wet wood. That report identified the sponson and outer rub rail with advanced decay. Today, this condition has worsened throughout the vessel's sponson and will continue to have detrimental effects on the vessel and specifically, the vessel's exterior mooring points until properly repaired or reinforced.

Photo 5

Image of Advanced Decay in 2020

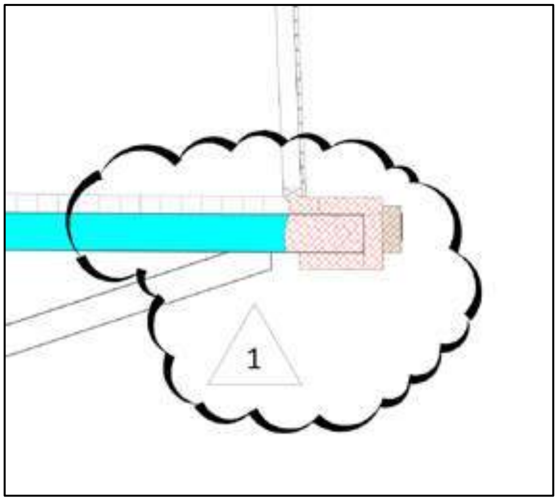

Figure 1

Illustration of the outer Sponson Rub Rail and location of advanced decay (Red Hatch)

Paddle Boxes

As was noted in 1990, and again in 2020, the enclosure surrounding the paddle wheels and more importantly the structure supporting outer paddle wheel drive shaft bearing are severely compromised.

This condition appears to be more prevalent on the starboard side of the vessel; however, there is advanced decay on both the port and starboard sides of the vessel in this area. One primary concern is that the weight of the outer portion of the paddlewheel assembly is supported by this structure and the truss structure, all of which are compromised. In short, the weight of the paddlewheel drive shaft is not properly supported, and this is likely causing a deflection of the drive shaft. Due to this prolonged condition, it is probable this deflection is permanent and will need to be removed (shaft straightened) before

the paddlewheel can be safely rotated or jacked over in the future.

The aft Hog Truss lower support beam on the starboard side of the vessel as noted in Photo 6, and illustrated in Figure 2 has advanced decay. The decay on this beam has progressed to the point where the end of the beam on the outboard side of the vessel has lost all strength and is caving in. This condition is affecting the strength of the entire truss structure and paddle box support system and must be repaired as soon as possible. See Photo 6.

Figure 2

Illustration of the vessel's Hog Truss and outer connection. Note arrow pointing to underside

Photo 6

Area under Hog Truss lower rod connection. Area depicted by arrow in Figure 2

Photo 7

Photo of starboard side support structure for paddle wheel enclosure. Note arrows point to advanced decay. (2020)

Photo 8

Photograph of area noted in photo 7 from 2021

Photo 9

Photograph of advanced decay proceeding aft of the paddle wheel on the starboard side of the vessel

Internal Steel Structure

The ship's main propulsion walking beam engine rests on a series of steel box structures which in turn are mounted on fore and aft beams that rest on the vessel's floor timbers. This box girder constructed and installed during the vessel's 90% rebuild completed in 1922[1] is a series of ½" flat plate and ½" angle iron fabricated and joined together with riveted connections. The box girder is incorporated into the walking beam engine structure. Of particular concern with this structure is the nature and extent of the corrosion that is present on various components of the steel assembly. Considering the walking beam engine is not operational, much of the corrosion can be considered cosmetic; however, there are some areas where it has become excessive especially where the steel is in direct contact with wet wood. In these areas, the steel may require evaluation and in extreme cases will require repair. The extent of the repair will depend on the amount of plate loss and criticality of the area in question. Importantly, due to the construction of the box girders and its location in the lower bilge much of that structure cannot be easily examined. Based on the condition of the structure that is visible it should be assumed that this condition is prevalent throughout, especially in the lower areas of the bilge and in areas with limited access. (See Figure 3.)

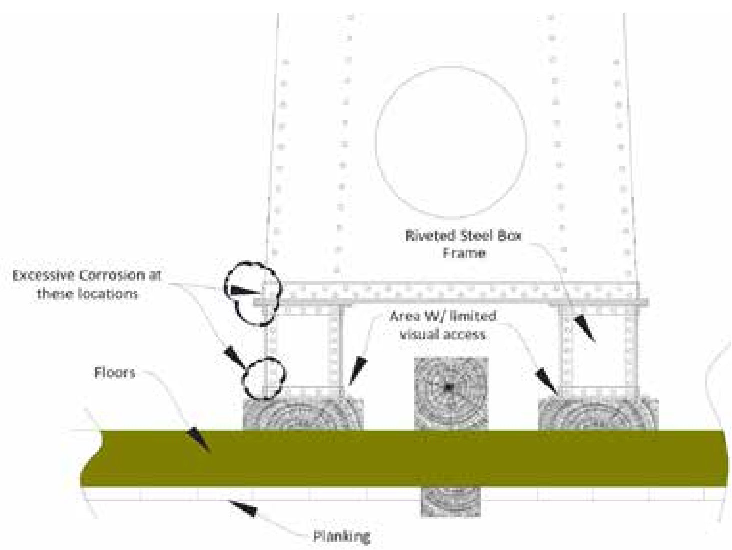

Figure 3

Section views of Steamer Eureka's main engine foundation noting areas with excessive corrosion. View at approximately Frame 8 looking into crankcase.

[1] Sourced from Northwestern Pacific Railroad Company invoice dated Aug 23, 2922

Internal Structural Fastenings

The following is quoted from the 2020 report regarding the *Eureka's* fasteners:

"*During the 2020 examination of the vessel there were numerous indications that the fastening systems on the Eureka were in critical condition. Fasteners in the lower frames were noted and, in some cases, were found to be corroded down to a small fraction of their original diameter (Note that a fastener corroded to half its original diameter has lost 75% of its cross-sectional area, and thus 75% of its strength.) The same condition was observed in the exterior hanging knees and in the upper and lower sheer clamps in both peak compartments on the vessel. Steel fasteners and bleeding rust were noted on the interior and exterior structural components.*"

In 2020 the fasteners in wet wood were the primary survey target. While it is difficult or impossible to remove and inspect all of the structural fasteners in the hull, the few that were examined in 2020 showed signs of severe corrosion. Knowing that the vessel's fasteners did not improve in the past 12 months, the focus of this survey was to determine if fasteners in other more sheltered and presumably drier areas of the hull had aged any less severely than their counterparts in wetter locations. In October 2021, I was able to inspect a fastener connection on a deck beam to carlin connection without removing the fastener. This area of the vessel is protected by the vessel's superstructure, so moisture contents of those beams and carlins, would be expected to be considerably lower than in parts of the wooden structure in the vessel's bilges and in hull planking below the waterline, where moisture contents are higher.

Photo 10, and Photo 11 were taken during the inspection of the fastener in question. Due to the size of the timbers in this location of the vessel, the fastener in question is presumed to be a 7/8" diameter bolt. The bolt seen in the picture is extensively corroded, and the expansion of the resulting rust has damaged the end of the deck beam. The corroded diameter is not evident in the picture, but the diameter has been reduced by more than 80%.

Photo 10

End of deck beam at carlin in the starboard side of the vessel in the engine room

Photo 11

Close up of photograph 11

Photo 12

Image of Staging for repairs to the aft pilot house

While this particular fastener is a relatively small concern in and of itself, the fact that a fastener in a drier location exhibited such extreme corrosion illustrates the full scale of the problem. In 2020, fasteners in wet wood were shown to be a grave concern, now in 2021 it is clear that fasteners throughout the vessel, regardless of the moisture content of the associated timber are a concern and would need replacement. I must point out that the condition of the vessel is beyond the point where simply replacing fasteners, or installing new ones nearby, would have much of an effect. Replacing fastenings is only effective where the wooden timbers being fastened together are in good condition. Even a discussion about "replacing fasteners" could be perceived incorrectly, as it may lead to the impression that the condition of the wood part of the structure is adequate, needing only new fasteners. In fact, the wood structure is actually in its worst condition immediately adjacent to where the fasteners are, due to the physical and chemical damage caused by the rusting of those fasteners.

Improvements Since Last Survey

Over the last twelve months the park has made considerable progress in repairing portions of the superstructure. The repairs include:

- refurbishing the forward pilot house corner windows,
- repairing the men's restroom dome deck including removing and replacing structural timbers suffering from advanced decay and renewing the waterproof membrane on the roof.
- painting of the dome and hurricane decks with an elastomeric paint. The elastomeric paint is part of the waterproof membrane system that maintains the watertight integrity of the upper decks,
- painting the overhead of the passenger and main decks outboard of the sliding doors at the bow and stern.

Conclusion

The *Eureka* is a complicated structure, which relies on wood timbers connected together by steel fasteners and supported with steel diagonal straps to remain intact, watertight, and safe for the public. It cannot be overemphasized that time has taken its toll on this vessel. Decay and other forms of deterioration continue to degrade the vessel's timbers and corrosion of the vessel's structural fasteners continues to slowly compromise the overall strength of the vessel. While improvements in some of the superstructure have and are currently being completed, (as noted above) those improvements are largely cosmetic in nature. And, while those improvements present the public with a better image of the historic vessel, to date they have not addressed the underlying structural problems. A complete and wholistic approach is required to address the steamer *Eureka's* increasingly inadequate structural condition.

Given the maritime historical significance of the vessel, consideration must be given how to best preserve the look and feel of the *Eureka.* This is in no small part to the sheer quantity and quality of wood that will be required during the restoration process, and not to mention the ever-shrinking population of skilled labor required to undertake this monumental effort. Regardless of the outcome, the *Eureka* as it sits today will continue to age and will need constant capital improvements to be maintained as an attraction at the park.

Appendix F

Eureka Conditions Assessment Final Peer Review Manager's Report

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Eureka Condition Assessment
Final Peer Review Manager's Report
2022-08-15

To: Todd Bloch, Project Manager, San Francisco Maritime NHP, NPS

From: Ben Becker, Peer Review Manager, Science Advisor, Californian Cooperative Ecosystem Studies Unit, NPS

Contents

1. Background

The *Eureka* is a double-ended, wooden-hulled, sidewheel passenger and automobile ferry launched in 1890. She was in service until 1957 and in 1963 went on display as a museum ship. *Eureka* has undergone numerous repairs, but her hull is largely original. Significant deterioration of the wooden hull and related metal fasteners has been observed.

In 2020, the report "Final Task Order Report on the Structural Condition the Ferry *Eureka* Revision 2" was completed by a team of marine technical specialists and naval architects.

In 2022, the report "Supplemental Structural Condition of the Ferry *Eureka* (Revision 1)" was completed by the 2020 team of marine technical specialists and naval architects. This report provided an update on the conditions observed in 2020. The 2020 and 2022 reports are referred to here as *Condition Assessments.*

In 2022, the National Park Service is preparing a Historic Structure Report (HSR) with a team that includes the same marine technical specialists and naval architects who prepared the reports above. The overall project team's concluding recommendation in the HSR, based on the condition assessment, is that the hull should be replaced in its entirety.

Eureka is scheduled for a major restoration effort within two years. The scope of work for that renovation will in a large part be based on the conditions found in these assessments – i.e., the scope will likely include replacement of the hull. The National Park Service therefore desired a *review* of the condition assessments to either support or refute the methods used, conclusions drawn and if the assessments reasonably support the recommendation to replace the hull.

National Park Service managers and maritime specialists decided that the *review* should be performed as a "peer review" and we therefore followed the peer review process described in *"Quality Control of Scientific and Other Scholarly Products in the Pacific West Region"* (July 2013).

2. Scope of the Peer Review

Typically, a peer review occurs before a document has been finalized to allow the authors to address and improve any concerns found by peer reviewers. However, in this case the Condition Assessments have been finalized and delivered to the National Park Service. Therefore, this peer review process was designed to provide the National Park Service with an independent assessment of the strengths and weaknesses of the finalized condition assessment for consideration in future management actions. The National Park Part Service may request that the Condition Assessment authors address the peer reviews or may include the peer reviews as additional documentation to assist NPS and others when assessing methods and conclusions of the Condition Assessments.

Peer reviewers were asked to review the entire document, and to specifically address these following priority issues that are critical to NPS planning:

- Based on the evidence presented in the assessments, provide expert opinion that the report satisfactorily supports several key conclusions, specifically that:
    - The majority of hull fasteners need to be replaced.
    - Hull fastener corrosion has damaged surrounding wood beyond repair.
    - Conditions readily observable can be extrapolated to the entirety of the hull – *i.e.*, the areas not visible are likely in the same deteriorated condition as the visible areas.
    - The overall conclusion that the hull has exceeded its life span and needs to be replaced in its entirety is supported by the condition assessment. A reoccurring question in discussions about the renovation scope has been if any of the original hull can and/or should be saved.
    - Other conclusions that may be deemed relevant by the reviewer.
- If relevant, discuss comparisons to other wooden ships that have faced similar conditions that the project team should consider.

3. **Peer Review Process**

Two potential peer reviewers with relevant expertise in ship restoration and repair were contacted by the peer review manager on June 21, 2022 and one reviewer (affiliated with Mystic Seaport in Connecticut) agreed to conduct the peer review and declined the customary practice to remain anonymous. The other peer reviewer declined due to retirement and not taking on additional work at this time.

On July 6, 2022, the Peer review manager sent the peer reviewer the (1) background, purpose, and scope of the peer review, (2) the 2020 and 2022 Condition Assessments, and (3) an optional peer review template to use while completing the review.

On August 7, 2022, the peer reviewer returned a completed peer review (using the NPS form template) to the peer review manager and the peer review manager began preparation of this report.

On August 11, 2022, a draft of this Peer Review Manager's Report and peer review forms were provided to the Project Manager at SAFR. The project manager asked for one clarification, which was confirmed with the peer reviewer. This Peer Review Manager's Report was finalized on August 15, 2022 and provided to SAFR.

4. Peer Review Findings

The peer reviewer conducted a thorough review of the Condition Assessments which is included in Attachment A – Peer Review Form. In summary, the reviewer found that:

- The report's propositions, hypotheses, assumptions, and limitations were clearly articulated
- The information was well-presented, logical, and understandable
- The objectives of the report had been met

Additionally, the reviewer found:

> *"…this report clear, concise, and based on facts derived from direct observation with little or no opinion presented by the authors. The experts conducting the assessment are widely recognized within their field. Their findings are further substantiated by appropriate scientific or other expert specialists contributing further substantiation of the findings."*

Additional strengths listed by the reviewer were:

> "*This document presents strong and useful knowledge that will enable NPS staff to make informed decisions regarding the future of the NHL vessel Eureka. Strengths are:*
> - *the expertise of the participants*
> - *direct observation substantiated through text, illustrations and photographs making points easily understood by lay readers*
> - *Logical sequence of presentation and format based on and consistent with previous assessment by earlier recognized experts from 1993."*

Limitations of the Condition Assessments were generally not related to findings or conclusions, but rather recommendations for improving report language to better communication of the full context of the findings for a lay audience. Specifically:

> *"The only limitations are:*
> - *the inability to directly observe elements of structure which are obscured by planking, ceiling and other aspects of structure.*
> - *Understanding the nature of a wooden ships structure and the interdependence of each element may be difficult for lay readers to recognize. The fact that one section may be observed as sound but will need to be removed either for access to deeper elements or provide sufficient overlaps for continuity of longitudinal strength is a challenge.*

- *Additionally, the critical importance of fastenings, for the most part unobservable to a lay observer may need additional amplification."*

Additional recommendations for clarification included:

> *"Greater emphasis on expected deterioration in areas not available for direct inspection due to obscuring elements of structure"*
>
> and
>
> *"Perhaps more information regarding percentage of structure directly observed compared to that obscured from inspection to give general reader a better picture of comprehensive view of condition."*

Based on the reviewer's comments in the context of the peer review priorities listed in Section 2, we can conclude strong peer reviewer support for the Condition Assessment findings. The reviewer indicated that *"All conclusions are supported by evidence".* Relevant peer reviewer comments addressing peer review priority questions are provided below in **bold**:

Peer Review Priority Issues to be addressed

Based on the evidence presented in the assessments, provide expert opinion that the report satisfactorily supports several key conclusions, specifically that:

- The majority of hull fasteners need to be replaced.
  - **Relevant Peer Reviewer comment: *"Additionally, the critical importance of fastenings, for the most part unobservable to a lay observer may need additional amplification."***
- Hull fastener corrosion has damaged surrounding wood beyond repair.
  - **Relevant Peer Reviewer comment: *"Greater emphasis on expected deterioration in areas not available for direct inspection due to obscuring elements of structure"***
- Conditions readily observable can be extrapolated to the entirety of the hull – *i.e.*, the areas not visible are likely in the same deteriorated condition as the visible areas.
  - **Relevant Peer Reviewer comment: *"Greater emphasis on expected deterioration in areas not available for direct inspection due to obscuring elements of structure"***
- The overall conclusion that the hull has exceeded its life span and needs to be replaced in its entirety is supported by the condition assessment. A reoccurring question in discussions about the renovation scope has been if any of the original hull can and/or should be saved. 4
  - **Relevant Peer Reviewer comment:** "***Understanding the nature of a wooden ships structure and the interdependence of each element may be difficult for lay readers to recognize. The fact that one section may be observed as sound but will need to be removed either for access to deeper elements or provide sufficient overlaps for continuity of longitudinal strength is a challenge.*** "
- Other conclusions that may be deemed relevant by the reviewer.
  - **Relevant Peer Reviewer Comment**: ***Limited options, restore wooden hull in-kind or replace hull with steel structure preserving element of original hull for exhibition***

If relevant, discuss comparisons to other wooden ships that have faced similar conditions that the project team should consider**. See the peer review form for discussion on the pros and cons hull replacement.**

Additional Peer reviewer comments on maintenance and historical significance of the Eureka.
The reviewer also provides perspective on the preservation and interpretive implications when considering replacement or repair of the hull. While these insights may be helpful as NPS considers alternative preservation actions based on the findings of the Condition Assessment, they do not necessarily reflect inadequacies or areas of improvement needed in the Condition Assessment.

Peer Review Manager's Conclusion: The peer reviewer found that the Condition Assessment's conclusions are well supported and reasonable. Additional useful recommendations and insights can be found in the peer review form (Attachment A).

5. Peer Review Manager Recommendations

The goal of this peer review was to improve the utility and robustness of the of the Condition Assessments for future NPS management actions and planning. Typically, authors would revise the reports addressing the peer reviewer conclusions. However, in this case (1) the condition assessments had been finalized prior to peer review, and (2) the peer reviewer was highly supportive of the Condition Assessment's conclusions and did not recommend any aspects of the report that needed major work (except one aspect of the abstract related to funding). Thus, any revisions would not materially change the conclusions of the condition assessments.

Therefore, I recommend that NPS make this peer review and Peer Review Manager's Report available to the public and managers when distributing the condition assessments.

6. Attachments

Attachment A: Completed Peer Review Form

Peer Review Form	PWR Science Program National Park Service U.S. Department of the Interior

To be filled out by peer review manager and additional reviewers as appropriate. The following material provides potential questions and rankings that may be appropriate to ask peer reviewers to address. The peer review manager should not feel constrained by these suggestions and should add, modify, or delete questions or text, as appropriate to the specific informative or influential scientific or scholarly product under review.

	Reviewer
Report Title: 2020 and 2022 Eureka Condition Assessments Report Series: NA	Name: Quentin Snediker Title, affiliation, and location: Mystic Seaport, CT I GIVE PERMISSION TO INCLUDE MY NAME ON REVIEWS PROVIDED TO THE AUTHOR(S) Yes X No☐

*Please answer each of the questions below as follows: **A,** adequate; **MI,** needs minor work; **MA,** needs major work; or **NA,** not applicable or not addressed. In your review memo, please be sure to elaborate about any aspect of the report you have rated as needing work.*

General Requirements	**A**	**MI**	**MA**	**NA**
Are the study's propositions, hypotheses, assumptions, and limitations clearly articulated?	X			
Is the information well-presented, logical, and understandable?	X			
Have the objectives of the manuscript been met?	X			

Section 1. Introductory Elements	**A**	**MI**	**MA**	**NA**
Does the title accurately convey the contents?	X			
Does the abstract provide a complete and accurate overview of the report? Does not address cost estimates.			X	
Does the abstract summarize the major findings or recommendations of the study? Needs to emphasis extremes of need.		X		
Does the introduction adequately define the problem addressed by the study?	X			
Does the introduction establish a need for the study and for the NPS involvement in it?	X			
Does the introduction include an appropriate statement of cooperation?	X			
Does the introduction include sufficient historical and background coverage to "set the stage" for the report/paper?	X			
Does the purpose and scope accurately and fully answer the question, "What will the reader find in this report/paper?"	X			
Is the description of the study area both adequate and relevant with respect to the purpose of the report/paper?	X			
Does the introduction include an appropriate literature review that puts the work in the context of previous work? More information regarding work undertaken since haul out in 1990's		X		

Section 2. Park-specific Information	**A**	**MI**	**MA**	**NA**
Are the geographic descriptors (such as borders and acreage) accurate for the time during which the study was conducted, and does the text appropriately describe any changes between when the study occurred and those at the time of publication?	X			
Is relevant park legal, historical, cultural, or natural history accurately presented? More information on regulatory status of the vessel regarding compliance with USCG, municipal and/or other entities for a vessel of its class recognizing its unique situation as a vessel with NPS ownership (If it is to be re-opened for visitation at some future date)		X		
Are statistics on park operations accurate? Not Provided in detail		X		
Is park-, regional-, or national-level management policies, guidance, or issues appropriately presented as part of the	X			

purpose for conducting the study? Perhaps more reference to *Secretary of the Interior's Standards for Historic Vessel Preservation Projects* as baseline for general reader.				

Section 3. Methods	A	MI	MA	NA
Are the study's propositions, hypotheses, and assumptions clearly articulated?	X			
Is the approach well documented and technically sound? Sound and professionally presented following industry standards	X			
Are key terms defined? Yes	X			
Are the sampling strategy and data-collection methods appropriate and adequately described or referenced?	X			
Are QA/QC methods appropriate and adequately described?	X			

Section 4. Results	A	MI	MA	NA
Do the results clearly address the question(s) posed in the introduction?	X			
Are all relevant data either presented in the report or adequately referenced?	X			
Are the results of QA/QC adequately presented and considered (if not already covered in the Methods section)?	X			
Has uncertainty been quantified appropriately? Greater emphasis on expected deterioration in areas not available for direct inspection due to obscuring elements of structure		X		
Were the appropriate statistical analyses performed? Perhaps more information regarding percentage of structure directly observed compared to that obscured from inspection to give general reader a better picture of comprehensive view of condition.		X		
Are the findings accurately and adequately described? Yes	X			
Are the conclusions reasonable and supported by the data and other evidence? Yes	X			
Are mathematical expressions clear and well defined? Perhaps an Abstract containing some simple explanations and definition of Hydrostatic/Stability analysis would be useful to general reader. Findings could be emphasized more strongly		X		
Are units of concentrations consistently used?	X			

Section 5. Figures and Tables	A	MI	MA	NA
Are all figures and tables necessary and introduced appropriately in the text? Yes	X			
Are all figures and tables clear and easily understood? Yes	X			
Do all figures and tables "stand alone"? For example, are table headnotes and footnotes fully explanatory? Yes	X			
Do maps include labels for all geographical references made in the text? A site plan showing position of vessel at the NPS facility would be useful in understanding references to "SF side" or "Oakland side" for readers not familiar with the site.		X		
Are data sources for maps cited in both figure captions and referenced in the "References" section of the report?	N/A			
Are the number of tables and figures adequate for this report/paper? Yes	X			

Section 6. Discussion and Conclusion	A	MI	MA	NA
Does the summary summarize the entire report (not just the results and conclusions), including a brief discussion of its background, and mention the cooperator(s)? Brief background and cooperators missing from Summary		X		
Are the conclusions justified by the data/ information presented in the report? Clearly	X			
Are alternative conclusions or counter arguments discussed and taken into account? Limited options, restore wooden hull in-kind or replace hull with steel structure preserving element of original hull for exhibition	X			
Are the results of the study discussed with respect to the results of previous work and other, similar research? Relies heavily on previous work by Tri-Coastal which I find a valuable and logical process	X			
Are all factors that might have contributed to the results adequately considered? Inevitable decay of wooden vessels, Lack of regular routine haul out and insufficient maintenance resources	X			
Are the conclusions free from speculative statements? All conclusions are supported by evidence	X			
Are management recommendations, if included, clearly supported by findings presented in the report/paper? Management recommendations only generally referred to but were not asked for in task assignment Option to construct steel hull to support Superstructure is valuable	X			

Section 7. Citations	A	MI	MA	NA

Have all data and interpretive statements that are not results of the current study or commonly accepted scientific knowledge been attributed appropriately in the text by means of citations? Clearly identified	X			
Are references and in-text citations formatted consistently according to NPS publication standards (or other standards depending on publication outlet)? Appear to be satisfactory, although I am not well versed in NPS standards for this issue				

Section 8. Appendices	**A**	**MI**	**MA**	**NA**
Is all information in appendices clearly related to the study but not essential for an understanding of the report and its conclusions? I believe some mention of recommendations of Hydrostatic Analysis and its importance to vessel preservation and general safety should be made Adding Curriculum Vitae for principle investigators would be useful Including Anamet Report on Fastening findings would also be helpful	**X**			

Section 9. Style and Format	**A**	**MI**	**MA**	**NA**
Is the title consistent with the first-order headings in the report? Yes	**X**			
Are new or unusual terms defined? No unusual terms, standard maritime language adequately defined for lay reader.	**X**			
Are mathematical expressions clear and well defined? Highly technical Hydrostatics Analysis could be summarized for lay readers				
Is the report easy to understand and appropriate for the intended audience? Yes	**X**			
Is the report logically organized? Yes	**X**			
Are the title and contents consistent? **Yes**	**X**			
Are the abstract, purpose and scope, and conclusions consistent and tied together? Yes	X			

Does this body of work, to the extent possible and practical, differentiate among facts, opinions, hypotheses, and professional judgment in stating the results of scientific and scholarly activities?

As a long-time maritime preservation professional, I find this report clear, concise, and based on facts derived from direct observation with little or no opinion presented by the authors. The experts conducting the assessment are widely recognized within their field. Their findings are further substantiated by appropriate scientific or other expert specialists contributing further substantiation of the findings.

What are the strengths, limitations, and potential usefulness to scientists, park managers, and others of the activity?

This document presents strong and useful knowledge that will enable NPS staff to make informed decisions regarding the future of the NHL vessel *Eureka*. Strengths are (1) the expertise of the participants, (2) direct observation substantiated through text, illustrations and photographs making points easily understood by lay readers (3) Logical sequence of presentation and format based on and consistent with previous assessment by earlier recognized experts from 1993.
The only limitations are (1) the inability to directly observe elements of structure which are obscured by planking, ceiling and other aspects of structure. (2) Understanding the nature of a wooden ships structure and the interdependence of each element may be difficult for lay readers to recognize. The fact that one section may be observed as sound but will need to be removed either for access to deeper elements or provide sufficient overlaps for continuity of longitudinal strength is a challenge. (3) Additionally, the critical importance of fastenings, for the most part unobservable to a lay observer may need additional amplification.

Additional Reviewer Comments

One of the biggest obstacles to be encountered in educating non-maritime professionals and even some staff is complacency. The vessel appears intact and has been afloat in position for nearly three decades. Initial observation does not reveal the depth of deterioration and consequent jeopardy the vessel is in.
Eureka is a huge wooden vessel by modern standards. The volume and quality of material demanded by a preservation project of this magnitude is staggering. The vessel was built at a time when tight grain old growth fir was the standard of industry. Today it is protected through most of its range in the United States and is near impossible to acquire within our borders.

The cost of routine maintenance for a vessel of this tonnage is also staggering. Resources necessary to ensure long term

preservation of the vessel should it be fully restored in all likelihood would not be available. Recent history has proven resources are insufficient to maintain the ship. In a few decades the nature of the structure would again need significant restoration.

Two examples of the inability to muster sufficient resources for large wooden vessel preservation are the 1897 National Register three masted schooner *Wawona* dismantled in 2009 (Non-NPS) and the 1915 National Historic Landmark steam schooner *Wapama* formerly managed by the NPS dismantled in 2013.

While possibly beyond the scope of this assessment the NPS is facing a difficult decision regarding a way forward to preserve the vessel. Even if resources were available for a full in-kind restoration and future maintenance, in today's world is this the most responsible course? The impact on resources, the environmental impact and demands on human capital might lead to a compromise. Substituting a steel hull under the historic superstructure has merit well worth consideration as pointed out in the assessment.

The 1993 Report by Tri-Coastal speaks of fuel oil and asbestos present in the engine room. No mention of remediation of these issues appears in the present study.

The cultural significance of *Eureka*, I feel, lies in the superstructure and propulsion system. Those areas that people have experienced directly. Interior joinery, mechanical systems and sheer volume of the interior spaces should be preserved. Subtleties and details of interior spaces need to be preserved. The details of hull structure and materials are for the most part, while critical, somewhat secondary to the bulk of human experience. Elements, even an entire section across the hull can interpret the technology of its era at a shore side facility.

Substituting a steel hull under extent superstructure may help avert the potential tragic loss of the National Historic Landmark vessel.

Appendix G

Assessment of Fastener Corrosion & Salt Damage

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Assessment of fastener corrosion and salt damage in the bilge of the Eureka

Interim report prepared by Samuel L. Zelinka and Grant T. Kirker

Purpose:

This report summarizes inspection of corrosion and salt damage on the ferryboat Eureka, built in 1890 and displayed at the San Francisco Maritime Museum of the National Park Service (NPS). The Forest Products Laboratory (FPL) was contacted by the NPS because of concerns about white "corrosion products" that were forming on metal bolts in the bilge of the Eureka. Photographs shared by NPS showed signs of salt damage on the wood in addition to corroded bolts. As a result of conversations between FPL and NPS, an inspection was conducted. This report summarizes the findings of the inspection and gives recommendations that can be used to preserve the Eureka and also make recommendations on possible actions to take during the next dry-docking of the ship.

Background- potential damage mechanisms in the Eureka

Corrosion

Under most conditions, metals are not thermodynamically stable. Corrosion is the process through which metals oxidize (corrode) to return to a more stable oxide state. While corrosion is nearly always thermodynamically favorable (i.e. it will happen eventually), the kinetics can be so slow that corrosion is not a concern for design.

When wood is wet, metals embedded in wood are subject to corrosion from extractives naturally available in the wood and potentially external chemicals added to the wood, such as wood preservatives. When the wood moisture content is below 15%-18% embedded metals do not corrode [1-3]. As the moisture content is increased above this threshold, the corrosion rate increases rapidly with increasing moisture content before plateauing at a maximum corrosion rate at approximate 30% moisture content [1].

The corrosion of metals in wood is greatly affected by preservative treatments; especially wood preservatives that contain copper, such as chromated copper arsenate (CCA), copper azole (CA or CuAz), or alkaline copper quaternary (ACQ) [4, 5]. In these wood preservatives copper ions from the preservative are reduced at the metal surface, which greatly increases the corrosion rate [6, 7]. In the absence of wood preservatives, embedded metals are subject to corrosion from native chemicals in the wood such as formic acid, acetic acid, and other small organic acids. Zelinka and Stone showed that the corrosion rate in untreated wood could be partially predicted by the pH of the wood and the amount of tannins in the wood [8].

Corrosion rates cannot be predicted from first-principles and therefore require at least some measurements taken in the conditions of interest [9].

Salt Damage

Salt damage occurs in porous materials in a two-step process. First dissolved salts are imbibed into the material. At a later stage, the water evaporates, causing supersaturation and later crystallization of these salts. The crystallization creates internal stresses in the material which leads to mechanical breakdown [10]. Salt damage has been well studied in stone and masonry materials. In these materials salt crystallization causes cracks to form within the material, which causes the surface to fall off and the mechanical properties to be weakened. In wood, much less is known about the exact mechanisms of salt damage and the extent that salt damage weakens wood [11, 12]. Salt damaged wood is easily identifiable by its characteristic "fuzziness", resulting from where the wood fibers have separated into long strands from the salt damage.

During the inspection, NPS shared documentation from the mid-20th century indicating that at one point, 1,200 pounds of salt were placed in the bilge of the Eureka as a wood preservation technique. The bilge of the Eureka was thus exposed to salt from the inside of the ship during the salt packing and also through seawater seepage from the outside of the ship.

Biodeterioration

When wood is in the presence of moisture and oxygen, it is subject to biodeterioration from fungi and to a much lesser extent bacteria. Molds grow on the surface of wood but do not impact strength while wood decay fungi are those that are able to degrade the structural components of wood. The following is a general overview of the different fungal types found on wood and how they are diagnosed (Figure 1).

A. **Mold fungi:** mold fungi grow on the surface of wood, but do not actively digest the wood structure. They can cause allergic reactions and discolor paints and coatings but do not significantly degrade any of the structural components [13]. The colorations of mold colonies are typically due to the presence of multitudes of pigmented spores that can easily be spread by wind or water. Mold fungi are extremely common and are frequent in areas of high moisture and low air flow.
B. **Brown rot fungi:** these are fungi are classified as basidiomycetes "true fungi", they produce enzymes and other compounds that break apart and digest cellulose from within the wood structure [14]. Wood with advanced brown rot has a rusty, cubical pattern on the surface that is mainly the remaining lignin matrix with most of the cellulose removed. Because these fungi are degrading the cellulose, rapid strength losses and structural failures are often associated with brown rot fungi. Brown rot fungi are often associated with softwoods, but they can degrade hardwoods as well [15].
C. **White rot fungi:** these fungi mostly belong to the basidiomycete fungi, but some are classified as ascomycete fungi "sac fungi" e.g. *Xylaria hypoxylon*. White rots have more specific enzyme systems that can break down both the lignin and cellulose in the wood. White rots are further split into selective or simultaneous based on their modes of decay. Selective white rots form

localized pockets of decay in the wood cell wall, while simultaneous white rot fungi degrade both components at the same time. Severely white rotted wood has a stringy bleached appearance and breaks of in stringy pieces [16]. Rotten firewood is a usually a good example of white rotted wood. White rots typically impact hardwood species, but can cause some decay of softwoods.

D. **Soft rot fungi**: these fungi are usually ascomycetes and are often associated with higher moisture contents and high amounts of available nitrogen. Soft rots cause localized pockets of rot in the S2 layer of the inner cell wall that can be severe. Soft rot typically occurs in water-soaked wood at the surface of the wood and results in gradual erosion of the wood surface. Advanced soft rot can lead to in place failures of wood [17].

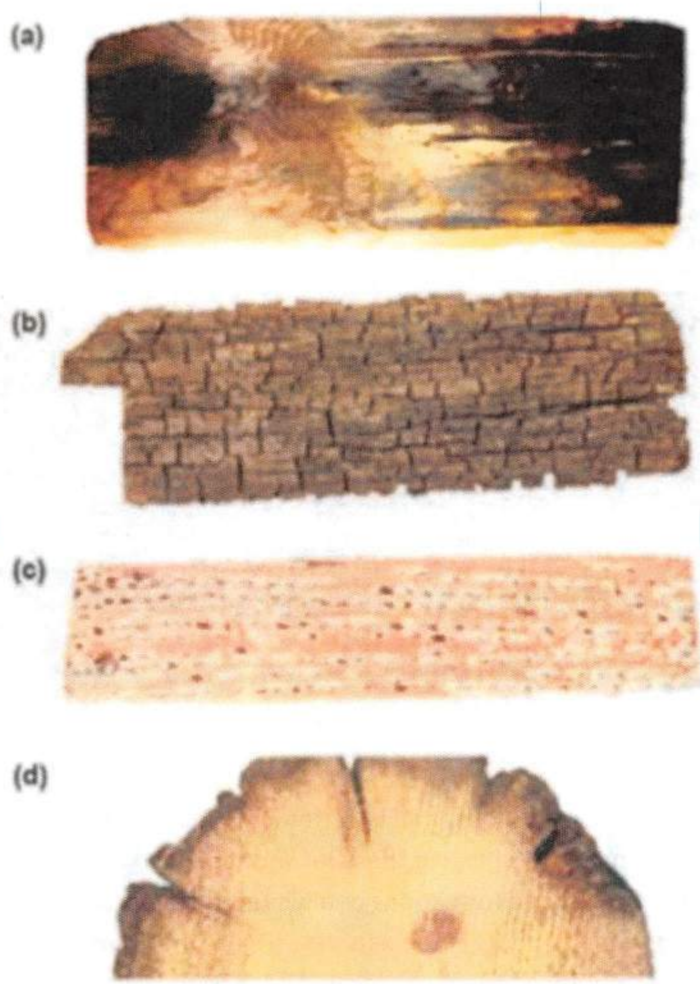

Figure 1: Characteristic images of biodeterioration on wood : (A) mold fungi (B) brown-rot fungi (C) white rot fungi (D) soft rot fungi.

Observations

Observations were taken at 2 locations in the bilge of the Eureka (Figure 2). The analysis area in the aft of the ship was referred to as the "Junior's Hold". There was no similar term for the analysis area in the forward bilge.

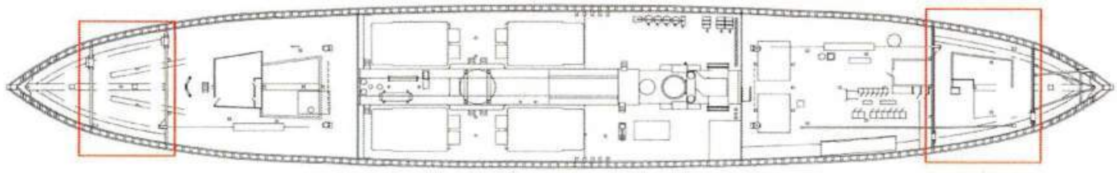

Figure 2: Rendering of the Eureka. The red boxes indicate the areas of the bilge that were analyzed.

Visually, the bilge in the aft of the ship was in better condition. There was less liquid water in that bilge. Also, there were new wood beams that had been added to support the deck above it. This was important as there were signs of structural failure of some of the old (original) joists (Figure 3).

Figure 3: (Left) new structural members to hold up deck. (Right) Structural failure of old wooden beams caused by salt damage.

The forward bilge had several inches of standing water in it. According to park service staff, there was no bilge pump in this section of the ship and there had not been a bilge pump for several years. In this section of the ship, there were large formations of a white substance (assumedly a result of corrosion) on top of each of the large metal boats in the keelsons (Figure 4). There was also a section on the side wall of the ship that was exhibiting brown rot decay (Figure 5).

Figure 4: White corrosion product on top of metal fasteners in the forward bilge.

Figure 5: Brown rot decay on side wall of forward bilge.

Wood Moisture Content

Wood moisture content is the most important environmental variable affecting corrosion, biodeterioration and salt damage. The corrosion rate of embedded metals increases rapidly as the moisture content is increased above 15% MC and eventually plateaus at a maximum corrosion rate at 30% MC. The optimal wood moisture content for fungal growth is 40-80% [18]. Salt damage occurs because of fluctuations in moisture.

A Delmhorst (RDM^3) electrical resistance moisture meter with 3" insulated pins was used to measure the wood moisture content. The probe was configured such that measurements could be taken at various depths. Measurements were taken throughout both bilges of the Eureka. However, in most of the measurements, the meter read "MAX" indicating the wood moisture content was greater than or equal to 60% (it should be noted that resistance moisture meters are very inaccurate for readings above 30% MC, and all readings above this level are an estimate[19]).

We believe that resistance moisture measurements were affected by the unusually high amount of salt in the wood. The moisture meter depends upon a relationship between electrical conductivity and wood moisture content for a given species. All of the wood in the Eureka showed clear signs of salt damage; this additional salt in the wood makes it more conductive, and results in the calculated moisture content being higher than the actual moisture content. Because of the high amounts of salt present in the wood of the bilge of the Eureka, electrical measurements of the wood moisture content will be inaccurate.

Instead, the moisture content was determined from increment cores taken from various locations in the bilge of the Eureka (Figure 2). Increment cores were collected and bagged immediately. Upon returning to FPL, the cores were weighed, oven-dried and reweighed.

Figure 6: Increment core being taken on a keelson near two corroded bolts identifiable by the white corrosion product blossoms.

The moisture content readings are given in Appendix A. In total, 16 gravimetric moisture content readings were taken. The moisture contents ranged from a low of 17% in the wall of the ship to a high of 88%, which was taken in one of the keelsons near a salt pile. The mean moisture content was 45%; the median was 34%. The measured wood moisture contents are in the range of wood moisture contents where corrosion and biodetrioration are likely to occur.

Remote Monitoring of Temperature, Humidity, and Wood Moisture Content

Eleven temperature and humidity sensors were deployed throughout the Eureka. Seven sensors were in the bilge, 3 sensors were placed below the deck but above the bilge and 1 sensor was placed on the deck. Additionally, 5 sensors that could measure temperature, humidity, and the wood moisture content (through an electrical resistance measurement) were deployed in the forward bilge. As with the wood moisture contents measured with the Delhmorst sensor, the moisture content readings from the remote sensors were influenced by the high amount of salt in the wood.

Figure 7 shows the daily average temperature in the forward bilge during the month of November. The temperature differences between the sensors were insignificant so the temperatures were averaged.

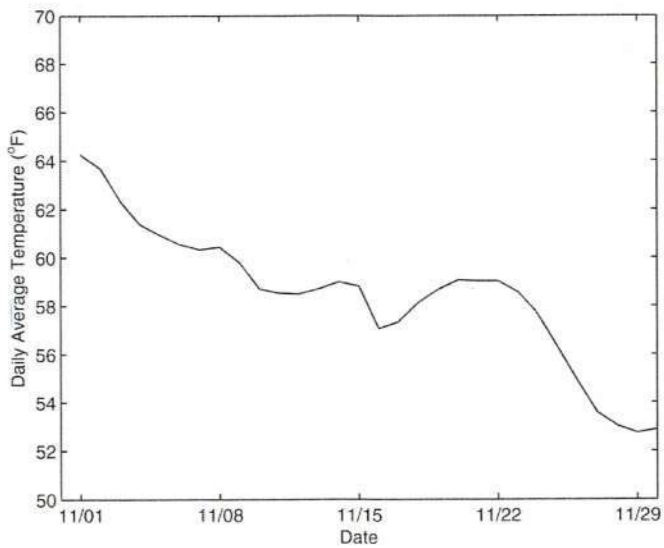

Figure 7: Daily averge temperature in the forward bilge during the month of November, 2015.

Figure 8 shows the wood moisture content (averaged on a daily basis) at 5 different locations in the forward bilge during the same time period. The sensors cannot read moisture contents above 40%. There was very little movement in the moisture readings throughout the month. All of the moisture readings were high, although it should be noted that the salt in the wood will increase the measured moisture content relative to the true, gravimetric moisture content, by an unknown amount.

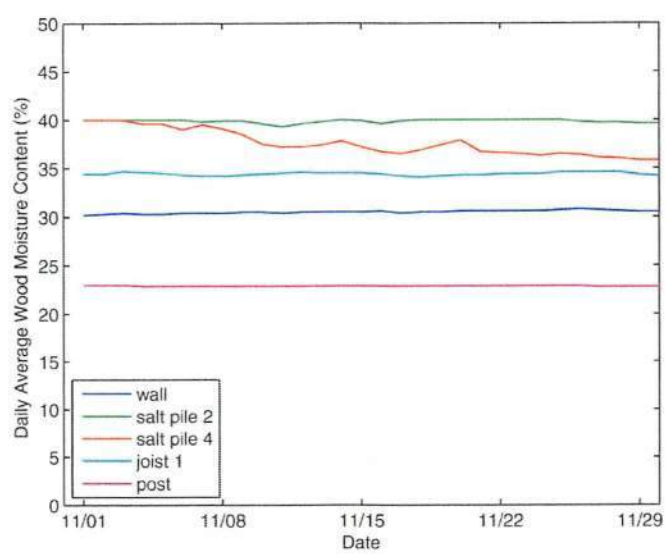

Figure 8: Daily average wood moisture contents (measured electrically) during the month of November, 2015.

Figure 9 compares the average hourly relative humidity in the forward and aft bilges in comparison with the relative humidity on the deck of the ship. Large fluctuations in the RH on the deck caused some fluctuations in the bilge, however, the fluctuations were very dampened. The variations in the RH in both bilges responded to changes in the relative humidity on the deck in the same way. However, for all measurements, the relative humidity in the aft bilge was lower (by about 10%) than the forward bilge.

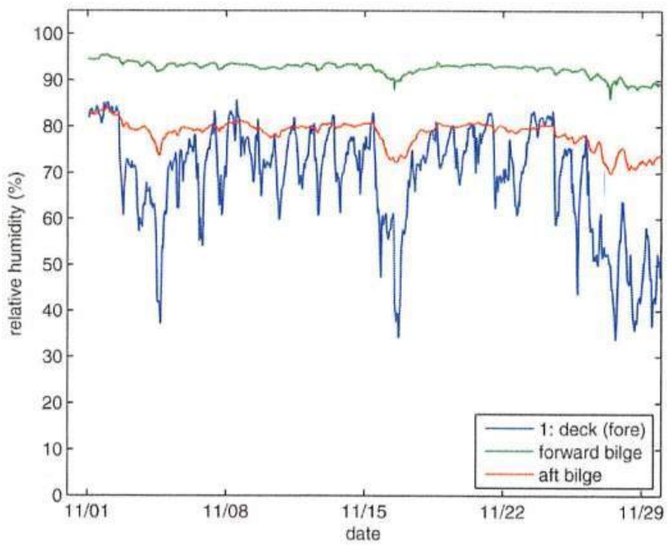

Figure 9: Hourly relative humidity measurements on the deck of the ship (blue) and in the forward (green) and aft (red) bilges.

Evaluation of white deposits and salt damage

To further evaluate and identify damage mechanisms in the Eurkea, increment cores were taken of the salt damage wood and analyzed using scanning electron microscopy (SEM). In addition, some of the white deposits were also collected and analyzed in SEM.

Figure 10 shows an SEM micrograph of the wood taken from one of the salt damaged joists (Figure 3). The SEM shows classic signs of salt damage where the tracheids are separated from each other and embrittled. The embrittlement can be detected by fractured tracheids. The "fuzzy" appearance of the salt damaged wood in Figure 10 comes from large agglomerates of these separated tracheids. The salt damage can also be observed by salt crystals, which appear as cubes along the trachieds. As part of the SEM analysis, Energy Dispersive X-ray Spectroscopy (EDS) was performed to identify the elements present. In addition to carbon and oxygen, the wood sample in Figure x contained large amounts of sodium, calcium, and chlorine, further confirming salt damage in the wood.

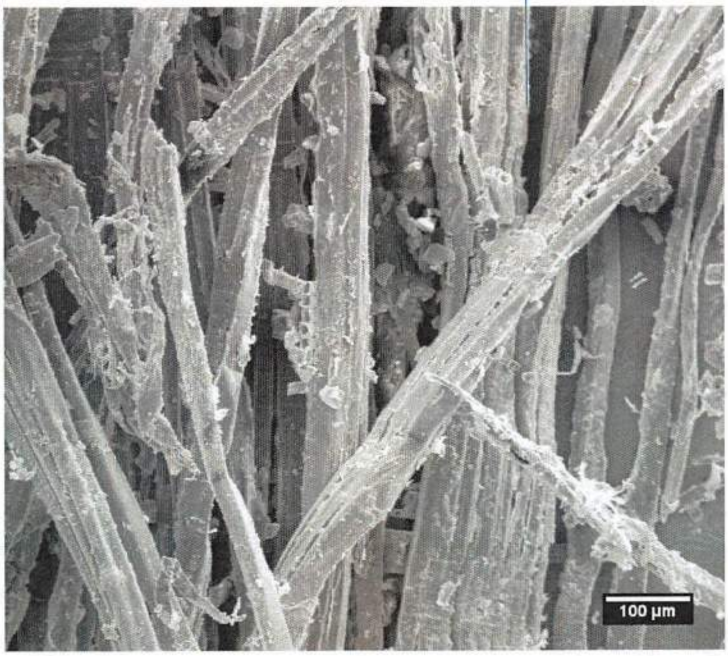

Figure 10: Scanning electron micrograph of salt damage wood taken from a joist in the forward bilge.

Figure 11is an SEM micrograph from the white corrosion deposit (Figure 4). The white deposit appeared mostly amorphous but contained some cubic crystals. EDS confirmed that the cubic crystals were indeed crystals of rock salt (NaCl). The amorphous region was predominantly sodium chloride with iron in it as well (presumably from the corroded fastener underneath the surface).

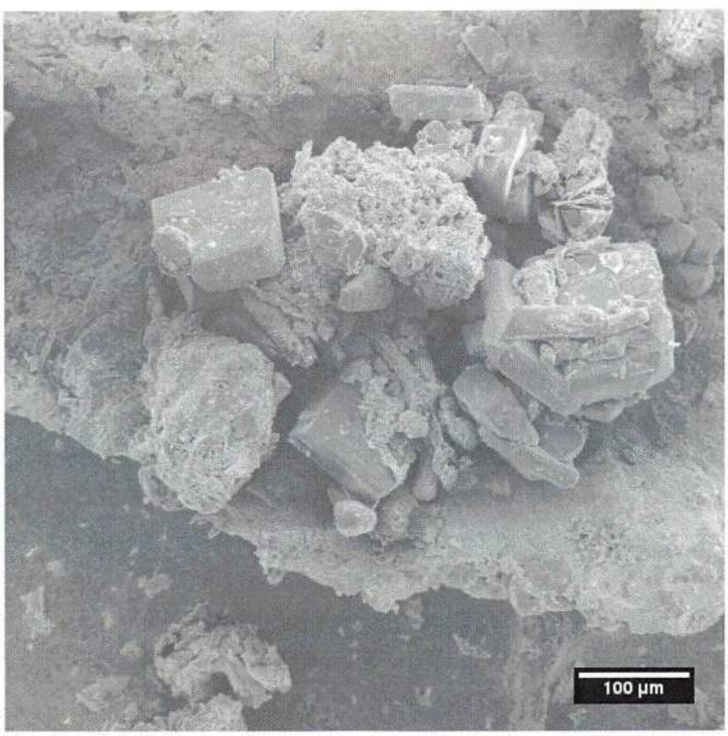

Figure 11: Scanning electron micrograph of a white deposit on top of a corroded fastener (Figure 4).

Continuing Measurements

During the inspection, ten carbon steel nails were embedded throughout the bilge of the Eureka. These nails were measured and weighed before being embedded so that the corrosion rate can be calculated. This corrosion rate can be used to estimate how quickly the bolts in the bilge of the Eureka are corroding. These corrosion rates can be analyzed with the method of Zelinka and Rammer [20] to see if this poses any structural concerns.

In addition to the SEM analysis of the salt damaged wood, it may be advantageous to also get quantitative salt concentrations from ICP, and also measure the pH of the wood. This would involve the collection of some extra increment cores by NPS staff.

Discussion and Recommendations

This report covers a preliminary investigation of the condition of the wood inside the Eureka. Corrosion experiments were started, but results from the corrosion test are not yet available. During the inspection, extensive salt damage was found throughout the bilge of the Eureka. Standing water was found in both bilges and the relative humidity in both areas was extremely high. As a result, the wood in the bilge of the Eureka was dangerously wet and are in the optimal range for corrosion and fungal activity. Failures may occur if mitigation techniques are not taken.

To preserve the Eureka, moisture needs to be removed from the bilge. Standing water needs to be removed. Furthermore, the high humidity in the bilge also needs to be controlled. In most modern commercial ships, active dehumidification systems are used to control moisture in the bilge. An active dehumidification system could be placed in the Eureka to keep the wood members at an acceptable moisture content and control salt damage. To prevent further salt damage in the wood, the relative humidity in the bilge should be kept below 70% [21].

The current state of the Eureka is ideal for conducting several valuable experiments aimed at understanding mitigation techniques and what types of rehabilitation will be most effective in the next dry-docking cycle.

- Corrosion: Currently, the Eureka is exhibiting ideal conditions for corrosion of metal fasteners. A corrosion test could be conducted by driving nails made from different metals into the wood. This could result in actual corrosion rates (in μm yr-1) for different metals in the Eureka. This information could be used to select the bolt material during the next dry-docking of the Eureka and also be used to predict how many years those fasteners will last in the rehabilitated Eureka.
- Salt Mitigation: It appeared that the posts in the bilge of the Eureka were painted; these posts appeared to have little salt damage and also had lower wood moisture contents than other parts of the ship. The bilge of the Eureka could be used to conduct *in-situ* experiments with different sealing materials to compare how well they could keep the wood dry and free of salt damage. Effective coatings could be deployed on the next dry dock.
- Dehumidification: Since the ship is almost a mirror image of itself and both the fore and aft bilges contained excessive moisture, a commercial dehumidification system could be installed in

one of the two bilges. This would allow comparative measurements of the effectiveness of the dehumidification system and also allow for the condition of the wood to be examined as it dries out with the dehumidification system. If successful, a permanent dehumidification system could be deployed in the next dry-docking of the ship.

References

[1] S.L. Zelinka, D. Derome, S.V. Glass, The effect of moisture content on the corrosion of fasteners embedded in wood subjected to alkaline copper quaternary treatment, Corrosion Science, 83 (2014) 67-74.

[2] N.R. Short, J.K. Dennis, Corrosion resistance of zinc-alloy coated steel in construction industry environments, Transactions of the Institute of Metal Finishing, 75 (1997) 47-52.

[3] J.K. Dennis, C. Zou, N.R. Short, Corrosion behaviour of zinc and zinc alloy coated steel in preservative treated timber, Transactions of the Institute of Metal Finishing, 75 (1995) 96-101.

[4] S.L. Zelinka, D.R. Rammer, Corrosion rates of fasteners in treated wood exposed to 100% relative humidity, ASCE Journal of Materials in Civil Engineering, 21 (2009) 758-763.

[5] S.L. Zelinka, Chapter 23. Corrosion of Metals in Wood Products, in: M. Aliofkhazraei (Ed.) Developments in Corrosion Protection, InTech, Rijeka, 2014, pp. 568-592.

[6] S.L. Zelinka, D.S. Stone, Corrosion of metals in wood: Comparing the results of a rapid test method with long-term exposure tests across six wood treatments, Corrosion Science, 53 (2011) 1708-1714.

[7] S.L. Zelinka, R.J. Sichel, D.S. Stone, Exposure testing of fasteners in preservative treated wood: gravimetric corrosion rates and corrosion product analyses, Corrosion Science, 52 (2010) 3943-3948.

[8] S.L. Zelinka, D.S. Stone, The effect of tannins and pH on the corrosion of steel in wood extracts, Materials and Corrosion, 62 (2011) 739-744.

[9] D.A. Jones, Principles and Prevention of Corrosion, Prentice Hall, Upper Saddle River, NJ, 1996.

[10] G.W. Scherer, Stress from crystallization of salt, Cement and concrete research, 34 (2004) 1613-1624.

[11] B.R. Johnson, R.E. Ibach, A.J. Baker, Effect of salt water evaporation on tracheid separation from wood surfaces, Forest Products Journal, 42 (1992) 57-59.

[12] N. Parameswaran, Micromorphology of spruce timber after long-term service in a potash store house, Holz als Roh-und Werkstoff, 39 (1981) 149-156.

[13] C. Alexopoulos, C.W. Mims, M. Blackwell, Introductory Mycology. John Willey and Sons, Inc., New York, 868 (1996).

[14] V. Arantes, B. Goodell, Current understanding of brown-rot fungal biodegradation mechanisms: a review, in: Deterioration and Protection of Sustainable Biomaterials, American Chemical Society Symposium Series Washington DC, 2014, pp. 1-21.

[15] T.L. Highley, Changes in chemical components of hardwood and softwood by brown-rot fungi, Material und Organismen, 22 (1987) 39-45.

[16] F.W. Schwarze, Wood decay under the microscope, Fungal Biology Reviews, 21 (2007) 133-170.

[17] J. Savory, Breakdown of timber by Ascomycetes and Fungi Imperfecti, Annals of Applied Biology, 41 (1954) 336-347.

[18] D. Griffin, Water potential and wood-decay fungi, Annual Review of Phytopathology, 15 (1977) 319-329.

[19] W.L. James, Electric Moisture Meters For Wood. U.S. Forest Service Research Note FPL-08, US Forest Service Forest Products Laboratory, Madison, WI, 1963.

[20] S.L. Zelinka, D.R. Rammer, Modeling the effect of nail corrosion on the lateral strength of joints Forest Products Journal, 62 (2012) 160-166.

[21] C. Price, P. Brimblecombe, Preventing salt damage in porous materials, Studies in Conservation, 39 (1994) 90-93.

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Appendix H

National Park Service Memo

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United States Department of the Interior

NATIONAL PARK SERVICE
San Francisco Maritime National Historical Park
2 Marina Blvd. Building E, 2nd Floor
San Francisco, CA 94123

IN REPLY REFER TO:

MEMORANDUM

DATE:	February 14, 2021; Updated: June 9, 2022
TO:	Project File – *Eureka* Historic Structure Report (HSR)
FROM:	Todd Bloch - Historical Architect, Project Manager
RE:	Repair/Replacement of Hull – Record of Discussions

PURPOSE

The purpose of this memorandum is to summarize meetings and discussions about the hull condition, the alternatives considered for repairing or replacing the hull and to make a recommendation for the "Recommended Treatment" section of the HSR.

CONTRIBUTORS

See attached "Attachment A – Participants and Contributors."

Tony Guild of Marine Technical Services provided review and editing expertise for this memorandum. All NPS HSR team members reviewed this memo and contributed to the content with varying levels of input.

BACKGROUND

Much of the nearly 300-foot-long hull, specifically, dates to the original construction of the vessel (as the ferry *Ukiah*) in 1890, although it is estimated that nearly 90% of the entirety of the vessel dates to the *Eureka* construction. Although some planking and structural elements, such as hanging knees, have been replaced over the years, the hull is generally original fabric.

Condition assessments were conducted in late 2019 and again, related to the HSR effort, in 2021.

The HSR project was initially entered into the Project Management Information System (PMIS) in 2015, the funding request submitted in 2019 and funding granted in 2021. The HSR was scheduled in part to inform an anticipated major restoration of the vessel in 2023 utilizing funding from the Great American Outdoors Act (GAOA).

The HSR team, including National Park Service (NPS) staff and consultants conducted a video conference meeting on December 2, 2021 to discuss the future of the vessel's hull (see also separate

meeting minutes). NPS staff participated in a Value Analysis (VA) discussion on January 10, 2022 and a follow up meeting on January 11, 2022, leading to this memorandum. Separate meeting minutes can be referenced for the December 2, 2021 and January 10, 2022 meetings; this memorandum serves at minutes for the January 11, 2022 meeting.

CONDITION OF THE *EUREKA*

The 2019 assessment found significant deterioration in major components of the hull – planking, keel, frames and fastenings were all noted as compromised. The 2021 assessment found further deterioration in these components plus the addition of rot in some major deck beams.

Several developments in recent years reflect the deteriorating condition of the hull:

- When *Eureka* was out of the water for a substantial drydock in 1993/1994; after a short period of time, several planks fell off the vessel. This was due to a complete failure of the plank's fasteners and lack of support from the surrounding water.
- In the mid-2000's the off-shore car deck needed to be supported by shoring in the hold.
- In 2021 storm surges pushed *Eureka* into her mooring slip and the shore side car deck began to crumble.

REPAIR OR REPLACEMENT OF THE HULL

On the December 2nd call, the HSR team discussed the possibility of repairing the hull in light of the deteriorated conditions. A primary question was if the hull could in fact be repaired or if it needed to be replaced in its entirety. It was recognized that the answer could have significant impacts on the historic fabric as well as project costs. The team felt that replacement is likely the only viable option. Reasoning for this conclusion includes:

- Fastener Sickness – direct observations indicate that a majority of the vessel's fasteners require replacements due to advanced corrosion. The deterioration of the vessels fasteners not only reduces their material strength, but it also has caused damage (delignification) to the surrounding wood, compromising the wood's ability to hold replacement fasteners. This renders much of the wood incapable of reuse.
- Extent of Deterioration – decay (rot) is affecting many of the vessel's visible structural timbers; due to the extent of this problem, many structural components that are not visible likely have similar issues. Considering that all damaged components will require replacement, this means extensive dismantling of the vessel to identify the extent of the problem and to facilitate the replacement of those components.
- Support of Engine Equipment – the hull supports all the weight of the engine, boilers and related equipment; leaving potentially deteriorated components to support this equipment could compromise the integrity of the hull. Also, there are significant concerns regarding the lower portion of the machinery's main steel support beam where it comes in contact with wet wood. This structure has considerable corrosion that will likely need to be repaired.
- Experience Restoring the *CA Thayer* – the NPS began restoring this wooden hulled vessel in 2003 with the intent of keeping as much of the historic fabric as possible. As the project progressed, more fastener damage and deteriorated wood was discovered ultimately resulting in the entire replacement of most the planking, frames and ceiling. Only the keel, adjacent planking and most of the hanging knees were saved. This change to the project scope led to delays and requests for additional funding.

Put simply, *Eureka's* hull is well past the end of its life cycle.

HULL TREATMENT ALTERNATIVES

Three alternatives for replacing the hull were presented and discussed at the Dec. 2nd meeting. The NPS team further considered the alternatives as follows, paraphrasing descriptions provided by the A/E team.

Alternative 1 – Replacement in Kind

Description

Replacement with new material copying the original shapes, sizes, and methods of construction. Although not preserving original fabric, it is a desirable option as it preserves the historic character to the greatest extent possible.

Discussion

This likely has the highest initial and life cycle costs. Initial costs would be high due to the difficulty in procuring materials (lumber of the size needed, replicating historic fasteners etc.) and the limited availability of labor and facilities to construct a wooden vessel of this size - it is noted that the vessel *CA Thayer* is approximately half the length of the *Eureka* at 156 feet – *Eureka* presents a much bigger challenge as the vessel has approximately four times the surface area and eight times the volume of the smaller vessel. The amount of material in a vessel's hull is at least in proportion to its surface area, in this case, likely even more than that. Additionally, the *C.A. Thayer* is an empty hull, with no internal bulkheads or decks below the main deck. So, the hull of the *Eureka*, below the main deck, alone, with internal decks and many transverse bulkheads, probably comprises far more than four times the amount of timber and metal fasteners as the *CA Thayer's* hull.

This alternative is best from an historic preservation perspective because replacement in-kind protects and continues the physical integrity of the resource. The continued ability of the vessel to remain in-water also preserves character and setting.

Life cycle costs would be vastly higher due to the maintenance required for a such a large wooden vessel. Again, *Eureka* is nearly twice as large as *CA Thayer* – transporting her, finding drydock space and sizable replacement lumber will be an increasing challenge. A wooden vessel requires more frequent haul outs than vessels of other materials due to the need to inspect the wooden components for rot, worm damage etc. *Eureka* is not suited for open ocean travel and given the decreasing number of shipyards in the Bay Area it will likely become more difficult to find a location that can readily put her in drydock without the construction of specialty equipment - an added cost for every haul out.

Another consideration is that reconstructing the hull out of wood will restart the process of deterioration that will ultimately lead to another hull replacement at a point in the future sooner than if other materials were used.

A variation of this alternative considered was replacing existing grown wood timbers with laminated wood members with the same geometry. This has been done on other park vessels including the *CA Thayer* and *Balclutha*. While this would address the difficulty in procuring full size lumber, deterioration and dry-docking challenges would remain. It was also important to note that using laminated wood is extremely wasteful – the process selects the best grades of wood, discards less acceptable pieces and each laminate is created with numerous plies of wood that are glued together to make up the dimensional part.

The process requires the plies to be sawn and fabricated from larger timbers. The waste generated from the fabrication process can mean that over two times the timber will be needed to fabricate each replacement component. Considering the *Eureka* is four times larger in timber volume that the *CA Thayer* this option would suggest the quantity of timber required would be over eight times the replacement in kind option.

Alternative 2 – Removal from the Water

<u>Description</u>

Remove the vessel from direct contact with open water and preserve it as an object. Options include incasing in concrete, placing the whole ship on a barge, as well as removing the topsides and putting them on dry land.

<u>Discussion</u>

These options all greatly degrade the visitor experience, turning a historical vessel into a museum piece - i.e. it is no longer experienced in context as a vessel in the water. There are significant technical challenges with these options. The lifecycle costs of these options will be less than Alternative 1 but would vary greatly based on approach.

This alternative is less desirable from a historical preservation perspective because removal of the vessel from the water would adversely affect character and setting, creating a static object removed from its context. Alterations required to address structural, and systems impacts would similarly have potential for adverse effects.

While it may seem beneficial to remove the structure from an environment that is contributing to its deterioration, similar efforts with other vessels have been met with significant challenges. (It should be noted that this discussion is specific to removal from water but remaining in an exterior environment. Many smaller vessels have been removed from the water and successfully maintained in interior environments; given the size of *Eureka*, indoor storage is likely not feasible).

There are examples of ships being encased in concrete however, they are generally steel hulled vessels. In any case, encasement is a questionable approach. Concrete itself is a corrosive material and it is porous which will allow water to migrate toward the hull. A barrier material could be installed between the concrete and hull, but it would still be susceptible to water leaking into the joint between materials. With no access to the hull for repairs, the moisture would hasten the deterioration of the wood.

Several challenges face a wooden vessel removed from the water and placed on land:

- Once removed from a moist environment, the wood shrinks as it drys, fastenings become loose, and the overall structure can weaken.
- The structure is still exposed to rain and if the hull is “opened” due to drying, water will infiltrate the structure and further advance deterioration from decay.
- Ships are designed to be supported by the water they sit in. If left out of the water for an extended period of time, and without the addition of an extensive new support system, the hull will deform.

Disconnecting the upper decks and topsides from the hull (thus eliminating the hull) and placing the remaining components on land (or on a barge) is not possible if the engine is to be retained. The engine is the primary feature of significance and it rests on the keel of the hull, with its components extending to above the upper most roof deck. Retaining the engine requires some sort of hull structure.

The National Park Service has direct experience with removing a wooden vessel from the water and placing it on a barge in the example of the NHL steam schooner *Wapama*. The vessel was placed on a barge in 1979 and a partial cover was installed directly on ship in 1985. Despite some attempts to maintain the vessel, no extensive effort was made to address the drying, ongoing deterioration and deformation challenges discussed above. After sitting on the barge for several decades, the *Wapama* was dismantled and disposed of in 2013.

A further consideration is finding a location for the vessel once out of the water. With a length the equivalent of a football field, finding a land-based location in the vicinity of the Hyde Street Pier based ship maintenance crew, and that is practical for visitor access, is not likely. Mooring a barge at Hyde Street Pier is also questionable. The *Eureka's* current mooring location is barely large enough for the vessel herself given the fishing piers adjacent to her slip. Space may exist in the Aquatic Park Cove, however given the barge's size, impacts to the Cove's historic recreational activities (swimming, rowing, sailing) may be adverse.

In summary, simply removing the *Eureka* from the water would do little to further the preservation of the vessel. In order to overcome the challenges of being exhibited out of the water, the hull would likely need to be replaced and extensively reinforced. This, combined with costs associated with creating the out of water location, would likely make this the most expensive alternative in terms of initial cost.

Alternative 3 – Recreate Hull with Non-historic Materials

<u>Description</u>

Replacement of the hull entirely with new construction and materials, duplicating the original shape, profile, and finished appearance of construction. The intent would be to preserve the overall historic character and appearance to the greatest extent possible while balancing life cycle maintenance. Options include laminated hull panels over existing frames and ceilings, or a new steel hull.

<u>Discussion</u>

This alternative is impactful from a historic preservation perspective. Historical character of the hull would be notably reduced or lost. However, other significant features such as the engine could be better preserved and the ability of the vessel to remain in-water preserves character and setting. With careful selection of material assemblies that are capable of replicating the shape, profile, and finished appearance of the hull on the exterior, while preserving interior elements as much as possible, the physical integrity of the overall resource would continue. Lower initial costs for the hull may allow funding to be directed toward preserving other areas of the ship.

A variation is a laminated wood external hull over as much existing internal structure that could be retained. While this option would allow the preservation of much of the existing internal structure, there was concern that it could be relatively more expensive than other options and not feasible on a vessel of this size. Unfortunately, this process will remove original historic fabric and feel of the vessel in the same way creating a replacement hull does and still requires some of the underlying structure to be replaced due to decay of the timber and corrosion of the fasteners. This approach would be an interim measure, and not do much to contribute to vessel longevity.

Converting to a steel hull would end *Eureka's* designation as a wooden ship. Given her status as one of the largest, if not the largest, wooden floating structures in the world, this is an important consideration. However, while utilizing a new steel hull would be a loss of historic fabric and character of the hull itself, the overall character of the ferryboat could be maintained. The team felt that it should be possible to

maintain many of the internal features, including ceilings and frame faces, to preserve much of the historic character inside the ship. The visitor experience of a ferryboat, including areas inside the hull such as the engine room, could be preserved.

A steel hull would reduce long term maintenance costs. Providing a new and more watertight hull will aid in the long-term preservation of the engine and related equipment as exposure to seawater and damp air will be reduced. The frequency of haul outs would be reduced. The skilled labor needed to repair a steel ship is readily available.

The non-historic hull alternative is a consideration of initial and life-cycle costs versus the extent of original character that is maintained.

VALUE ANALYSIS

On January 10, 2022, the HSR team participated in a preliminary Value Analysis (VA) discussion for the Great American Outdoors Act funded project for the *Eureka*. Although the VA did not directly influence considerations for the HSR, it did provide an opportunity to further discuss the condition of the hull and the feasibility of the alternatives listed above.

The technical consultants reiterated that the hull condition is frail. A particular question addressed was if areas of the hull not currently visible might ultimately be salvageable and if a decision on replacement could wait until such areas could be physically accessed and investigated. It was noted that achieving such access would require placing the vessel in dry dock and beginning disassembly. A specific challenge with this approach is that procurement for replacement material could not begin until the assessment is complete. Due to the challenges in sourcing and preparing material this process could take many months and likely over a year, a period during which the vessel would be sitting in dry dock at great expense and vulnerable to further deterioration.

Regarding Alternative 1 – Replacement in Kind, further specifics were discussed regarding the challenges to procuring wood for a full, or partial, hull replacement regardless of replacement in-kind or selecting the laminated option. It is likely that the amount of high quality old growth lumber required for the work is not available; harvesting old growth trees has become questionable due to costs, changes in forest stewardship practices, and from a sustainability perspective. Lower quality wood would be more susceptible to deterioration, resulting in a faster rate of deterioration and less time between haul out cycles. Lumber in the sizes required would need to come from newly felled trees, which can take year or more to "season." Acceptable lumber cannot be selected until it has been properly seasoned, so replacements for rejected lumber would restart the procurement cycle. Given the schedule for funding, and the deteriorated state of the ship, there cannot be delays in material procurement.

Regarding Alternative 2 – Removal from Water, this option was deemed unfeasible due to the challenges in securing a land-based location, the impacts to the vessel's materials and likely high costs as noted in the discussion above. This alternative was considered and dismissed from the VA. The HSR team also felt that this was not an appropriate treatment for the vessel due to the removal from context and the likely deterioration of historic fabric.

Regarding Alternative 3 – Recreate Hull with Non-historic Materials, it was noted that the definition of "hull" should be clarified. It does not necessarily mean the entire structure below the deck; the "outer hull" – planking, keel and framing, could be distinguished from the "inner hull" – ceiling, hanging knees etc. It would be possible to replace the outer hull with non-historic materials and either retain or replace in kind portions of the inner hull.

CONCLUDING MEETING

The NPS HSR team met via video conference on January 11, 2022, to attempt reaching a conclusion about repair or full replacement of the hull and the method to be recommended.

It was stated that the goal of the meeting was to determine a treatment recommendation based on the document "The Secretary of the Interior's Standards for Historic Vessel Preservation Projects with Guidelines for Applying the Standards" (the Standards). The Standards reference several types of treatments for historic vessels including Acquisition, Protection, Stabilization, Preservation, Restoration and Rehabilitation. Given the nature of the *Eureka* project, the discussion focused on two treatments – Restoration and Rehabilitation. The Standards define those treatments as follows:

> **Restoration**: the act or process of accurately recovering the form and details of a vessel as it appeared at a particular time by removal of later work, or by replacement of missing or substantially deteriorated earlier work.
>
> **Rehabilitation**: the act or process of returning a vessel to a state of utility through repair or alterations that make possible an efficient contemporary use while preserving those features of the vessel that are significant to its historical, naval architectural, technological, and cultural values.

Several statements from the Standards were also referenced, including:

- "…good historic preservation practice demands that the preservationist adhere to one basic precept in all work undertaken: to retain and preserve to the greatest extent possible the historic form and fabric of the vessel." (p. 10)
- "… ABSOLUTE REQUIREMENT that the vessel be kept structurally sound, weather resistant, and (in the case of a vessel afloat) watertight." (p. 12, emphasis in original)
- "Historic fabric will, of necessity, be replaced in the course of maintaining a sound, weather-resistant, watertight structure." (p.12)

Discussion

Through the several months that the NPS HSR team has been discussing the future of the *Eureka,* and specifically the hull, the group repeatedly returned to our responsibility to attempt to retain historic fabric and form. The condition of the hull (primarily the outer hull as defined above) was revisited and unique sources for securing lumber were sought; however viable preservation options remained elusive. In the context of *Eureka* and her deteriorated condition, the notion of "preserve to the greatest extent possible" is challenging concept, and the team increasingly realized that some features would be saved while others would be lost. Conclusions were not easily reached. Nearly all team members spoke to the difficulty, given our roles as preservationists, on deciding whether to remove historic fabric.

It was noted that the park has been in this position before when no action ultimately resulted in the loss of the *Wapama* and when a consideration to avoid historic fabric loss in the *CA Thayer* nearly prevented her restoration.

In response to the January 11th meeting and a subsequent draft of this memorandum, HSR team member Chris Edwards and former park historian Steve Canright requested further discussion on several topics (see email from Chris Edwards on 1/20/2022 with reply from Todd Bloch on 1/25/2022 – see Attachment B – Draft Memo Correspondence", and letter from Steve Canright on 1/18/2022). This correspondence is summarized below:

- Stainless Steel Sheathing in Lieu of Copper – Steve Canright inquired if this was feasible; Tony Guild offered comments in a memo - see "Attachment C - *Eureka* SS Sheathing Comments." To summarize that memo, stainless steel does not offer anti-fouling properties, is not conducive to the adherence of anti-fouling coatings and is susceptible to corrosion when emersed in seawater. The memo also discusses the challenges of using cathodic protection.
- X-Ray Scans and Non-Destructive Evaluation (NDE) Resistance Drill – Chris Edwards raised the possibility of using these methods of analysis to determine if usable wood remains in the vessel. Tony Guild confirmed that x-ray scanning could be put to use on *Eureka*, but his opinion is that it would mostly be effective with the fasteners rather than wood. Regarding the drill, Todd Bloch offered his understanding of the information to date; in summary – drilling would undoubtedly find good wood, but it would be in between areas of wood deteriorated by fastener decay. Given the number of fasteners likely causing deterioration in a timber component, the overall component is likely compromised and too segmented to allow splicing in of new wood.
- Laminated Timbers – Chris Edwards observed that unused wood might be able to be put to use for other purposes by a lumber yard or fabricator, especially if a contract could require such.
- Defense Logistics Agency (DLA) – DLA provide a path for securing larger timbers for the *CA Thayer* restoration. Both Canright and Edwards inquired if all avenues of procuring wood through DLA have been exhausted; it was reported that the DLA has not been contacted. It was noted, per previous comments, that *Eureka* would need four to eight times the amount of wood that was used for *CA Thayer*. Since availability of wood may depend on when a request is made (beyond the time frame of this HSR), it is suggested that a future project investigate this potential prior to excluding it.

A separate discussion also took place regarding the use of treenails in lieu of metal fastenings. The inquiry was regarding if the use of treenails in a new wooden hull would prevent further wood deterioration. Tony Guild prepared a memo – see "Attachment D - Treenails Memo" in response to this question. To summarize one point in that memo, treenails are used in wood-to-wood connections and would not be appropriate fasteners in locations where material other than wood is involved. In the case of *Eureka*, there would be many such locations.

The NPS HSR team recognized that this discussion does not entirely rule out benefit from or potential use of these approaches. However, the approaches all relate to maintaining a wooden vessel and many of the team members felt that the feasibility of initially restoring *Eureka* with a wooden outer hull is only part of a larger issue. The long-term issues associated with wood - faster paced deterioration, increased maintenance, dry docking challenges etc. are also of concern.

After considering the discussions as outlined in this memorandum, a majority of the team (with member Chris Edwards and former historian Canright dissenting) supported the following conclusions:

- Regarding repairing or replacing the outer hull, the team concluded that the expert opinions we solicited, and experience with our own vessels, indicate that the outer hull cannot be saved and would need to be replaced. However, it was felt that some portions of the inner hull could be saved or replaced in kind.
- Regarding material for a replacement outer hull, the team concluded that the challenges of material availability, maintenance issues and a shorter-term replacement cycle made wood unfeasible.

The HSR effort provided the opportunity to rule out alternative outer hull materials and recommend a wood replacement hull. Ultimately the team majority decided that a hull constructed of a long-term durable, and more easily maintained, material would likely best serve the historic vessel and should be

considered an acceptable treatment. A stable outer hull will better protect other significant features and allow more resources to be directed toward the preservation of those features.

RECOMMENDATIONS

It is recommended that the outer hull be replaced in its entirety and to accept a non-wood material as an option for the construction of the replacement. This recommendation should not be seen as outright approval of any alternative material; a future project pursuing this option will need to prepare a detailed design solution that will be subject to standard Section 106 compliance review. Although restoration in wood is seen as not feasible, it should not be entirely ruled out if future resources and commitments can overcome the challenges identified in this memorandum. The general treatment would be Rehabilitation if an alternative hull material is selected - the vessel's wooden outer hull would be replaced with a more durable and easily maintained material to accommodate its contemporary long-term use as a museum ship. A hull constructed of an alternative material likely best facilitates preservation of the vessel as a whole, supports an achievable long-term maintenance program and provides a realistic haul out cycle. If the hull is replaced in kind with wood, the general treatment would be restoration.

The replacement outer hull should reflect the shape, form, and massing of the historic hull including character defining features such as the sponsons/outriggers supporting the overhanging car deck and rudders. In general, the historic form and appearance of the hull should be maintained. While the outer hull maybe a contemporary material, the inner hull should retain the wood construction in certain areas, including in the engine room; contemporary components should not be outwardly visible in these areas.

The new hull needs to support the engine, boilers, and related equipment without alternation to that equipment and accommodate the activation of the walking beam and rotation of the paddles.

Eureka should be exhibited afloat in the water.

Attachment A – Participants and Contributors

Names in **bold** are members of the NPS *Eureka* HSR team.

Name	Organization/Position	Meetings: Dec. 2	Meetings: Jan. 10 (VA)	Meetings: Jan. 11
David Brouillette	NPS/SAFR – Superintendent	X		
Bert Ho	NPS/SAFR – Division Lead, Cultural Resources and Museum Management	X	X	X
Phil Erwin	NPS/SAFR – Senior Manager, Ships and Facilities	X	X	X
Morgan Smith	NPS/SAFR – Manager of Interpretation, Education and Volunteers	X	X	X
Jonathan Dille	NPS/SAFR – Chief of Administration and Business Services (Acting Superintendent, January meetings)	X	X	X
Jeff Morris	NPS/SAFR – Supervisory Facility and Historic Ship Operations Specialist	X	X	X
Chris Edwards	NPS/SAFR – Interpretive Ranger	X	X	X
Diane Cooper	NPS/SAFR – Museum Technician	X	X	X
Elizabeth Pidgeon	NPS/SAFR – Historical Architect, Project Manger	X	X	X
Todd Bloch	NPS/SAFR – Historical Architect, Preservation Manager (HSR PM)	X	X	X
Stephen Canright	Retired – NPS/SAFR – Historian			X
Tony Guild	Marine Technical Services (HSR consultant)	X	X	
Brian Thomas	Naval Architect (HSR consultant)	X		
Ryan Mitchell	RPA – Project Manager	X		
David Wessel	ARG – Principal	X		
Stacy Farr	ARG – Planner, Architectural Historian	X		
Gary Murakami	ARG – Architect	X		
Jennifer Baker	NPS/Denver Service Center – Project Specialist *Eureka* GAOA Project (*Eureka* GAOA Project)		X	
Jason Himick	NPS/DSC – Project Manager (*Eureka* GAOA Project)		X	
Christa Nye	NPS/DSC – Natural Resource Specialist		X	
Ed McClave	McClave Marine (reviewed memorandum only)			

Organization Key:
NPS/SAFR – National Park Service/San Francisco Maritime National Historical Park
NPS/DSC – National Park Service/Denver Service Center
RPA - Robert Peccia & Associates, Inc. – Architect/Engineer prime contractor for *Eureka* HSR
ARG – Architectural Resources Group – Architect/Engineer sub-contractor for *Eureka* HSR

Attachment B - Draft Memo Correspondence

From:	Bloch, Todd
To:	Edwards, Christopher
Cc:	Smith, Morgan M; Ho, Bert S; Dille, Jonathan E; Erwin, Phil; Pidgeon, Elizabeth A; Morris, Jeffrey; Diane Cooper; Hijar, Katherine N
Subject:	RE: Comments Regarding the Final Draft Memorandum on Alternative Hulls
Date:	Tuesday, January 25, 2022 2:12:00 PM

Hi Chris,

These are all good questions and I think having them considered and addressed will indeed be of benefit to the HSR document. Thank you for your observations and thoroughness, all part of a robust team effort. With that in mind, I've taken the liberty of including the HSR team in my response to keep everyone in the loop.

A couple of things I think should be kept in mind:

- The feasibility of initially restoring Eureka with a wood hull is only part of the equation. The long-term issues of faster paced deterioration, increased maintenance, dry docking challenges etc. are also of concern.
- This HSR is not the final statement on what a restoration project will be. In this case we are providing a range of options and the parameters within which those options should be implemented. The HSR, in my opinion, should address the context in which an historic structure exists – costs, time, physical resources, labor resources, etc. – and make recommendations that include options that are achievable within that context. It should also weigh benefits to the structure as a whole versus benefits to a component of the structure.

I don't think I can definitively answer all your questions, but here's what I can offer:

X-Ray Scans –I understand this technology has been used on somewhat large wood objects/structures. Tony Guild confirmed that it could be put to use on *Eureka,* but his opinion is that it would mostly show the condition of fasteners, not so much the wood.

Metal Bridge Expert - I did take a look at the website. I'm a little skeptical that he could assist with the metal fastenings, but the girder under the engine is a possibility. However, the part of the girder Andy showed me was literally crumbling so I would wonder how much could be saved. Steel is easier to procure than large lumber so it would seem possible to defer a decision about extent of replacement – i.e. wait until it is more visible. I don't think we made a hard determination that it needs to be entirely replaced (I'll check the memo language); a future project should probably anticipate the possibility of replacement but allow for retaining material if possible.

Non-Destructive Evaluation (NDE) Resistance Drill – It is very likely, if not certain, that testing would reveal "good wood" in some locations somewhere in the hull; Tony agrees with that. The issue is that good wood, in between locations where there is fastener rot (and thus damaged wood), does not mean the overall wood component could be reused. The fastener locations are important because that is where the structure is being held together and if that wood is bad, then the whole piece is probably compromised (of course there is the possibility of splicing in new wood but given the frequency and proximity of fasteners the areas of good wood are probably relatively small, meaning there would be multiple splices). I suppose if the drilling could be so precise that we could drill right next to a fastener that could be useful. However, given the number of fasteners in the ship, there would need to be a lot of drilling to get enough information to be helpful. Perhaps that is

where the thought that drilling would not provide enough information came from.

Laminated Wood – I think this is a good question, seems logical that the excess wood could be used somewhere. However there still is the issue of harvesting a lot of trees. I think it was Tony who mentioned that we'd need to harvest eight times the amount we'd actually use in the ship. I'm not really sure how to evaluate these environmental questions – is natural material better than fabricating steel? – hard to say, we really don't know. I think it might be best to avoid environmental impact discussions and just mention the need to deal with the waste wood.

Defense Logistics Agency – it can't hurt to ask and have that information/explanation in our pocket. We'll need to remember that (per Ed McClave's observations about the volume of the Eureka) we need over four times the amount of wood that was used for CA Thayer. We also need to keep in mind that procuring wood is not the only issue, time to season it and confirm its usefulness is a factor. Documenting outreach to the Defense Logistics Agency could be something a future project pursues.

Review of the HSR – the HSR will not go out for public comment, but a future project would be very much open to public comment through PEPC. Remember that the future project is where a specific hull material will be formally proposed. This is also when SHPO would comment – on a project; and the HSR will likely be included with the SHPO project submittal. The Advisory Council on Historic Preservation, regional and national NPS NHL advisories would also be invited to comment. SHPO likes to see that other interested parties are actively invited to comment, so we'd reach out to maritime preservation organizations as well.

Acceptance of the HSR – I'm not aware of a required decision-making process related to HSR discussions. The approval process for the final HSR document is generally a signed recommendation from the project manager, signed concurrence from the Chief of Cultural Resources and signed approval from the Superintendent. It appears our region also has another approval step with the Regional Director, but I am awaiting confirmation of that. I think this HSR team's approach is to make recommendations, based on input from a fair representation of staff and subject matter experts, and supported by a majority of the team. If we ever get to a point where there is notable disagreement, we'd need to figure that out. The recommendations then are subject to the approval process outlined above where they may, or may not, be accepted. I think the project meeting minutes and records should reflect how the recommendations where made – consensus, majority opinion etc. Where there are dissenting opinions, those should be noted.

My perspective on a wood hull - the question is not if a wood hull is technically possible, but rather given how much wood, how much time, how much money and how much future maintenance is required, is building and sustaining a wooden hulled vessel of this size practical with the resources that will likely be available? Furthermore, will these resources be available in time to save the entirety of the vessel before unrepairable damage occurs? The HSR is not ruling out wood; however, it is anticipating that there will not be resources to support a wooden vessel, whether new or restored. The HSR is thus providing for an optional alternative material that will facilitate preservation of a majority of the structure.

I’ll take another pass at the hull memorandum and revise to make clear the above points. I will also clarify the decision-making process.

If any of the team has comment, please chime in.

Thanks,
Todd

From: Edwards, Christopher <Chris_Edwards@nps.gov>
Sent: Thursday, January 20, 2022 3:45 PM
To: Bloch, Todd <Todd_Bloch@nps.gov>
Cc: Smith, Morgan M <Morgan_Smith@nps.gov>
Subject: Comments Regarding the Final Draft Memorandum on Alternative Hulls

Hi Todd.

In regards to the memorandum about alternative hulls, I remain concerned about moving forward on replacing it with steel. I realize that the majority of the group has decided to go with this option, but despite the time limitations, I feel that we really need to be clear to SHPO and others that we have been thorough in eliminating all other options.

First, how about non-destructive testing using x-ray technology for wood and ultra sound for metal structures and fittings? There are companies that specialize in this and apparently some universities have programs that may help or do this for free as it furthers their own goals, such as the Forestry and other programs at UC Davis and UC Berkeley? Much of this could certainly be done with the vessel in the water and would prevent long in-drydock time/expense.

I also realize that the engineer on the project has already noted in detail the state of the metal fastenings, but we could also consider another specialist to confirm these findings. Especially given the gravity of this decision and its impact on this NHL. One possibility might be Vernon Mesler. I have only just looked him up, but he apparently works with Lansing Community College in Lansing Michigan. His main work apparently relates to old metal truss bridges, but given their nature and the riveting on these bridges, his kind of specialty should be applicable to metal fittings and especially the metal box girder under the engine. His website is:

http://www.historicbridgerestoration.com

I also would like to re-mention what I enquired about at the last meeting. The resistance-measuring/ density drill. It seems to me that this drill (which we have in-house) would provide us with more data. The argument against it was that it would not provide enough information to determine not to move forward with hull replacement, but can we say that with certainty? In any case, why not use it if we actually have one in the park. It is my understanding that more data is always more useful than less data and if we use the above non-destructive techniques, it might provide a lot of useful date.

As for possible laminate use, one outstanding concern is the wastage resulting from it. Again… I am a novice with this subject matter, but do companies who use laminates not recycle this waste into products such as plywood and particle board? Could we ask or offer the contractor to reuse this waste material in such a manner? The park may not necessarily benefit directly from it, but if the material is handled in this way, then at least we would know it is not really waste and our mandate as an agency devoted to environmental protection would stand well with this. Additionally have we evaluated the carbon foot print difference between steel and laminate? This would also contribute to being less environmentally impacting.

Based on the meeting we had yesterday (1-19-22) when Stephen Canright asked if the Defense Logistics Agency had been queried, the response was that they had not as no one currently at the park knew how to reach out to them. Stephen Canright replied that Michael Bell had been involved with them on the Thayer project and that he could be asked about it. Should we not at least ask Michael to reach out to them (or ask him how we can do so) and acquire a definitive answer about whether they can help acquire lumber? If we have not done so already, then when SHPO asks about this, how can we honestly answer that we have a definitive “no” from them? So far it seems that our discussion of this has implied that we cannot rely on this agency, but have we actually asked them yet?

Finally, does the replacement of the hull need total consensus of the HSR team and will it go out for public comment? If it needs consensus, it will be difficult for me to do so. If the majority of the team decides that we really need to replace the hull with steel can this memorandum also capture that it was not a unanimous decision, but that the majority decided it was what was needed?

I apologize for the length of this message, it I appreciate your time for it.

Attachment C - *Eureka* SS Sheathing Comments

□ **Anti-Fouling**.

Overlapping sheets of nearly-pure copper have been used at least as far back as the 18th century to prevent underwater marine fouling of wood vessels by both animals (like barnacles) and plants (like various seaweeds and algae). In addition to pure copper, other common copper alloys containing at least 70% copper are also inherently anti-fouling, but some of those alloys (like silicon bronze) are not suitable for direct exposure to sea-water due to other characteristics, like susceptibility to accelerated corrosion in moving water.

Stainless-steel has no anti-fouling properties, although some types of fouling do not adhere to stainless-steel as tenaciously as they do to other materials. Because stainless-steel is not inherently anti-fouling, it would have to be protected by anti-fouling paint. However, paint adheres only poorly to stainless-steel, even in environments that are much-less-severe than immersion in sea-water.

This leaves pure copper, and 90-10 copper-nickel, as the only readily-available non-fouling and non-exotic metals suitable for sheathing wood hulls.

□ **Stainless-steels**

The common types of stainless-steels are not suitable for use in sea water, particularly in thin sheets, because of their corrosion characteristics. The stainless-steel alloys that are suitable for use in sea water are much more expensive than the common alloys, and are used only in small amounts for critical applications (such as propeller shafts), and they are normally cathodically-protected. Cathodic protection (see explanation of cathodic protection below) of such a large area of metal would in itself be an expensive strategy, requiring continual maintenance, for a vessel with as much underwater surface area as Eureka.

□ **Crevice Corrosion of Stainless-steel**

Stainless-steel suffers from a particular type of corrosion called Crevice-corrosion. Crevice-corrosion is initiated when the chloride ions of sea-water break down the natural protective film that stainless-steels form when wet, and then a lack of access to oxygen in the water prevents that film from self-repairing (which it usually does when exposed to moving, fully-oxygenated sea water) would. Crevice-corrosion typically occurs to stainless-steel surfaces shielded from exposure to open, flowing water. Sea-water entering crevices or shielded locations on metal surfaces contains microorganisms that consume and thus deplete the dissolved oxygen in the water. If that water is not readily refreshed, it becomes depleted of oxygen. If the metal is stainless-steel, this creates the classic environment for crevice-corrosion to initiate and to progress.

Typical locations for crevice-corrosion of stainless-steel include: the back sides of metal sheets in contact with wet, absorbent, materials like wood; fastenings embedded in wet wood; parts of stainless-steel surfaces shielded from open exposure by marine growth; areas behind peeling protective coatings, and many more. Metal sheathing is typically, and pretty-much necessarily, installed with laps between the sheets to prevent entry of organisms. A mechanical lap joint between individual stainless-steel sheets would be a classic location for crevice-corroion to initiate.

- ☐ **Cathodic Protection**

Cathodic protection, either by connecting plates of special zinc or aluminum alloys to the metal to be protected (sacrificial-anode cathodic protection), or by providing protective DC currents from a power source (impressed-current cathodic protection) can prevent sea-water immersion corrosion of the exposed surfaces of underwater metal sheets of most types of metal, including stainless-steel. Cathodic protection is usually used to protect small areas of necessarily-exposed metal or to protect large painted metal surfaces from corrosion at small flaws in the paint or at small locations of physical damage to the paint film. Cathodically-protecting large areas of exposed, uncoated metal that would otherwise be susceptible to corrosion is very expensive.

- ☐ **Cathodically-protecting metals in contact with wood.**

Cathodic protection of any metal produces alkalai chemicals that eventually deteriorate wood in contact with the protected metal. While layers of insulating material like tarred felt are often used between wood hulls and their metal sheathing, the fastenings (which generally need to be of the same material as the sheathing), that affix the sheathing to the hull, penetrate the insulating material and thus wood around those fastenings eventually deteriorates due the effects of cathodically-protecting the sheathing.

- ☐ **The effects of cathodic protection on marine fouling**.

Applying cathodic protection to immersed metal surfaces, while preventing corrosion to openly exposed parts of the surfaces, also renders inherently-anti-fouling metals susceptible to fouling. Thus, cathodically-protecting underwater surfaces of pure copper or of high-copper alloys will result in marine fouling of that surface. So, any cathodically-protected underwater surface, regardless of its alloy composition, must be painted with anti-fouling paint to prevent fouling.

Cathodically-protecting any underwater metal surface results in electrochemical plating of calcium compounds onto the surface. These compounds are the material that the shells of marine organisms like clams and barnacles are made of, and they provide a perfect substrate to which live fouling organisms can attach.

- ☐ **Exposure to sea-water**.

Any metal sheathing system on the underwater portion of a wood hull will eventually admit water, unless the individual plates are actually welded at the joints like a continuous metal hull. Any lapped-plate sheathing system, even if insulated from the hull by various impregnated fabrics or sealants, will eventually allow water to enter, and thus the underwater planking of any metal-sheathed vessel will eventually be saturated with sea-water and the back-side of the metal sheathing will eventually be directly exposed to sea-water. If the sheathing is stainless steel, the depletion of dissolved oxygen in the water on contact with on the back side of the sheathing will make it very susceptible to crevice corrosion. Crevice-corrosion causes pitting, rather than overall surface wastage, and with thin sheets of material, even a small amount of crevice-corrosion will cause failure of the metal membrane.

Attachment D - Treenails Memo

Ref: (1) 1943 ABS Rules for Building and Classing Wood Vessels

Subj: Could Treenail Fasteners replace some or all of the metal fasteners in the Ferry Steamer Eureka's Structure?

The ongoing discussion regarding restoration of the steamer *Eureka* raised the question of using treenails (trunnels) to replace some or all of the vessel's metallic fasteners. Treenails are advantageous because they cannot corrode. This is in stark contrast to the extensive corrosion noted in the vessel's existing fasteners. The presumption behind the question is that the use of treenails could substantially reduce the need for future fastener inspection and replacement.

The Eureka was built in 1890 as the Ukiah, designed by Patrick H. Tiernan and built by John Dickie at the San Francisco and North Pacific Railway yard in Tiburon, California. The fasteners that hold the timber of the *Eureka's together* include nails, spikes, screws, lag screws, drift bolts, bolts over clinch rings, and double ended bolts. There is currently no indication that treenails were ever used in the construction of this vessel. For reference, there are over 25,000+ plank fasteners, 15,000+ ceiling fasteners, 2,000+ futtock frame fasteners, hundreds of backbone fasteners, easily a thousand bolts for the clamp and shelf structure and 20 to 30 thousand deck fasteners. Last, but not least, there are over 240,000 fasteners holding the copper sheathing on the vessel.

In general, the frame bolting, hogging strap fasteners and copper sheathing fasteners could not be replaced with treenails, yet nearly all of these exhibit corrosion or outright failure. It is possible that the planking and ceiling fasteners could be replaced with treenails, and it would reduce the impact of corrosion in the future. However, as a practical matter, this approach in infeasible. The fabrication, drilling and fitting of the treenails is relatively highly skilled work with experienced practitioners in short supply. Additionally, while the fabrication of the treenails themselves is possible, they are far more expensive than the equivalent metallic fastener. Finally, substituting treenails for the original fasteners where allowed can only be accomplished if the timbers are sound and free from defects. Considering the number of fasteners required, the costs and lack of labor, as well as the paucity of timber in acceptable condition for treenails, the costs of this approach exceed the benefits.

<u>For additional information regarding the general acceptability of treenails see the following:</u>

While there several standards for large wood vessels, the United States Coast Guard currently still recommends the use of reference (1) for scantlings. That document describes among other things the minimum fastener(s) required to ensure the structural integrity of a vessel. As a result, in formulating an opinion regarding the question asked, reference (1) was used. While the referenced standard is dated, and the *Eureka* will not be seeking Classification, the need remains to ensure the entire structure is capable of carrying the static loads of the vessel while moored. Using the referenced standard helps to ensure that the vessel's structure is restored to an acceptable standard.

Section 119 of reference (1) outlines the general requirements for Fastenings on a large vessel. That section states:

(1) The diameter of fastenings required for the various members in the vessel structure is based upon the thickness of the member fastened; the number of fastenings required for any member in the vessel structure is based upon the type and area of the member fastened; all fastenings must be driven thoroughly tight, failure to comply with this requirement will render the vessel ineligible for class.

(2) members that are exclusively attachments, such as knees as in table 109-D, or stems, sternposts, aprons etc., as in table 119-A are to have one fastening per square foot of surface; structural members, whether or not they are also attachment members such as shelving, lodgers, etc., R2 have two fastenings per square foot of surface fastened.

(3) the number and diameter of fastenings required are tabulated for specific purposes as follows:

ITEM	TABLE No.
Stem, sternpost, Rudder post, Aprons, Shaftlogs, Deadwood, Transom, Deck Girders, and Hatch Coamings	*119-A*
Keel, Keelsons, Keelson Riders, Engine, Thrust, and Boiler Foundations	*119-B*
Waterways, Lockstrakes, Shelves, Clamps, Lodgers, Breast Hooks and Pointers	*119-C*
Floor Ceilings, Bilge Extension Ceiling, Bilge Ceiling, Tween Deck Ceiling, Ceiling in Poop Bridge and Forecastle enclosure	*119-D*
Planking	*119-E*
Main Rail and Rail Stringers	*119-F*
Bulkheads	*119-G*
Knees	*119-D*
Diagonal Strapping	*111*

Table A

(4) Fastenings in the vessel structure not specifically covered by these tables, or in the sections pertaining to them, or to be fastened in accordance with Par. 2 of this section.

(5) where for any reason, the tabular fastenings are not adhered to, the fastenings used must be increased in diameter, we're in number to the equivalent of the tabular requirements.

IRON FASTENINGS

(6) I am fastenings are to be of the best material, and we're exposed or liable to saltwater contact from seepage or other cause, they are to be galvanized; elsewhere they may be driven black.

(7) the holes for iron fastenings are to be bored 116th less than diameter of the bolt; where for any reason two drift bolts are used, each drift is to equal the half length of bolt, and the difference in diameter between the two drifts to be 1/16 inch, in all cases the smaller diameter is to be that required by table.

(8) all blunt bolts should be round pointed; spikes maybe round, of the tabular diameter or they may be square end of a size equivalent to the tabular diameter; in either case there to be parallel sided for 3/4 of their length, and have a fair taper to the point.

YELLOW METAL FASTENINGS

(9) fastenings in contact with Yellow Metal sheathing or fittings, end external fastenings with a distance of 12 inches from Yellow Metal sheathing or fittings under water, are to be made of Yellow Metal.

(10) Yellow Metal fastenings or to show by analysis a proportion of not less than 60% of copper; they are to stand having the head flattened out and of being cold riveted without revealing splits or cracks.

TREENAILS

(11) Treenails maybe black or yellow locust or Live Oak, thoroughly seasoned, and made entirely of heartwood; they are to be free from spike knots or knots in clusters, worm holes, any form of rock or decay, powder post, or incased bark.

(12) Treenails or to be finished smooth and true to the diameter required by table, which may be uniform in treenails of not more than 20 inches in length; treenails have greater length are to be tapered to give a drift of 1/16 inch in the diameter; or two drift treenails of two uniform diameters may be used in lieu of tapered treenails, when the latter are not obtainable each drift to be equal to half length of treenail and the difference in diameter between the two drifts to be 1/16th inch; in all cases the smaller diameter is to be that required by the table,

(13) the length of treenails is to be in accordance with the thickness of the material fastened and whether the treenail is to be long, driven through and wedged, or short and blind, the latter should not in any case exceed 22 inches in length. The lengths of long and short treenails relative to thickness of material fastened should be as required in table 119-E.

In short while the use of treenails presents an option in the restoration of the *Eureka* it might not be the best option available.

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Appendix I

Accessibility Video Meeting Memo

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Eureka HSR – Accessibility Video Meeting – January 19, 2022

Attendees: Phil Erwin, Morgan Smith, Jonathan Dille, Bert Ho, Chris Edwards, Diane Cooper, Jeff Morris, Katherine Hijar, Todd Bloch

Recorded by: Todd Bloch

Relative to an overall concept, the team considered two general approaches for disability access to the deck levels of the ship:

- Internal to the vessel via one or more lifts
- External to the vessel via a lift on the pier or an adjacent floating dock, with walkways to each deck

The external option could include a through hull penetration below the car deck to access the engine room (either directly or through one of the holds fore or aft of the engine room). It was noted that there could be technical issues with openings near the waterline, clearance issues with the sponsons etc. and the movement of a barge versus the ship. However, it was recognized that technical issues could be addressed in the development of future projects and this discussion should focus on the potential negative impacts the of alternatives relative to the positive increases inaccessibility.

An external "tower," with stairs and a lift, would prevent impacts to the internal fabric of the structure but could have impacts to the hull if the through hull approach was pursued. (*recorder's note: a tower may also have view shed/site line issues related to the historic district and park neighbors*). However, passengers historically accessed the passenger deck by a very similar method - i.e. a raised structure adjacent to the ship. Sliding gates on this deck that opened to allow access are still present on the vessel.

The team considered what visitor experiences are desirable and what spaces should be open to visitation, and then considered what impacts to historic fabric, character, context etc. might be acceptable to achieve those experiences and access. The team concluded:

- Hurricane deck and pilot houses – as with all ships, the pilot house, ship's wheel or tiller is one of the primary locations a visitor might want to experience as it is the "control center" of the ship. However, the team re-confirmed the previous conclusion that this area is not accessible on the Eureka without significant impacts to historic fabric and the appearance/character of the ship. There is no stair upon which a platform lift could be installed and there are not internal spaces to conceal an elevator/lift on both the passenger and hurricane decks. The rooms behind the pilot house are so small that an elevator/lift would occupy nearly all, if not all, of the space. The pilot house itself is raised above the hurricane deck by several feet, further complicating a means of providing access. Here again, the pilot house is too small to accommodate an internal elevator/lift.

  Access via the previously mentioned external tower would result in a tower height and associated gangway to the deck that would significantly interfere with the appearance of the structure. Accommodating the weight of the gangway would require structural reinforcements of the deck that could not be concealed. Again, access to the hurricane deck would not provide access to the pilot house.

  In summary, physical access to the hurricane deck and pilot house should not be provided. It would require the addition of a new elevator/lift enclosure rising above the hurricane deck,

effecting historic fabric and dramatically altering the appearance of the vessel. A programmatic solution should be pursued for this area.

- Passenger Deck – this is another key experience on the vessel as it is where passengers historically sat during transit across the bay; providing access to it is a primary goal if not a requirement. It was noted that there are several locations where an elevator/lift could be installed from the car deck to the passenger deck. The team recognized that providing access to may result in an elevator/lift being visible on either deck but found this to be acceptable to achieve access. If an elevator/lift cannot be concealed, it should clearly be presented as a modern addition.

  (recorder's note: it was not discussed in the meeting, but the merits of a platform lift on one of the stairs should be noted. While likely technically possible, such a mechanism would have a significant visual impact to the highly prominent stairs. A safety issue is that fire/life safety codes require [Balclutha as an example] that platform lifts do not block exit routes if they become non-functional in the middle of the stair; the stairs on Eureka are not wide enough to accommodate the platform and provide sufficient exiting width.

  In summary, access to the passenger deck should be provided. The external tower concept is preferable, an internal elevator/lift is acceptable. The least visible and least impactful location for an internal elevator/lift should be sought and the device either concealed or clearly contrast with historic fabric.

- Engine and Engine Room – these are also high priority targets for access as it is often noted that the walking beam engine is a primary reason the vessel was saved.

  It was noted that the engine extends through all three deck levels and is not limited to the lower hold engine room; the walking beam itself is above the dome deck. This is pertinent in that seeing the engine does not necessarily require being in the engine room, in fact, being in the engine room only reveals a portion of the overall engine apparatus. The team thus discussed the opportunity to open existing hatches and cutting new openings to increase visibility of the engine. New openings could include removing decking (possible filled with glass) and removing larger portions of the engine casing. It was noted that new openings would need to be limited, locations carefully selected and be reversable to prevent contributing to an adverse effect.

  The team has previously noted the value of being in the engine room and experiencing the spaces as if they were a crew member, something that can only be accomplished through direct access. The team has discussed, in several previous meetings, creating access to the engine room proper but concluded that dismantling of the engine or its components should be avoided since the engine is a primary, if not the primary, feature of the vessel. This means however that there would be no improved access to the engine room.

  This meeting did not reverse the earlier conclusion that access not be provided. However, it was noted that new ideas, such as the external tower with lower hold access, or accessing an adjacent hold and entering the engine room indirectly may allow some degree of access and the HSR should allow for future projects to investigate such options.

In summary, some areas of the decking and engine casing should be opened to increase visibility of the engine though care should be taken to avoid an adverse effect. The engine or its components should not be disassembled to create access, but some slight modifications may be acceptable.

Appendix J

Bibliography

ARCHIVAL COLLECTIONS

California Department of Parks and Recreation Statewide Museum Collections Center. Northwestern Pacific Railroad Collection.

San Francisco Public Library, History Center. San Francisco Maritime Museum subject file.

San Francisco Maritime National Historical Park. Maritime Research Center. Harrison Dring Papers, *Eureka* Historical (1911-1985).

San Francisco Maritime National Historical Park. Maritime Research Center. Resource Management records, *Eureka.*

PUBLISHED SOURCES

Cullivan, Lynn. "1890-1990 *Eureka*, A Centennial Retrospective." *Sea Letter* (Journal of the National Maritime Museum Association), No. 42, Spring/Summer 1990.

Daily Alta California.

Dear, I. C. B. and Peter Kemp. eds. *The Oxford Companion to Ships and the Sea*. Oxford: Oxford University Press, 2006.

Delgado, James P., and National Park Service Maritime Task Force. *National Register Bulletin 20: Nominating Historic Vessels and Shipwrecks to the National Register of Historic Places*. U. S. Department of the Interior, National Park Service, Washington, DC, 1992.

Demoro, Harre W. *Electric Railway Pioneer: Commuting on the Northwestern Pacific, 1903-1941.* Glendale, California: Interurban Press, 1983.

Evanosky, Dennis. "Alameda in History: Failed Railroad led to Thriving Ferry Service." *Alameda Sun*. July 17, 2015.

Foisie, Jack. "Rebirth of an Old Ship." *San Francisco Chronicle*. September 23, 1963.

Haller, Stephen, National Park Service. Eureka *National Register of Historic Places Inventory Nomination Form*, San Francisco, CA, 1984.

Harlan, George H. *San Francisco Ferryboats*. Berkeley, California: Howell-North Books, 1967.

Harlan, George H., and Clement Fisher. *Of Walking Beams and Paddle Wheels; A Chronicle of San Francisco Bay Ferryboats*. San Francisco: Bay Books, 1951.

Kortum, Karl. "Why I Picked the *Eureka*," *Sea Letter* (Journal of the National Maritime Museum Association), No. 42, Spring/Summer 1990.

List of Merchant Vessels of the United States. Washington: Government Printing Office, 1868, 1876.

Nance, R. Damian. "The Paddle Steamer *Eureka* and its Walking Beam Engine." *International Stationary Steam Engine Society Bulletin*, January 2018.

No author. "*Ukiah* is Launched, Makes Maiden Trip (article made up of full printing of two news articles from *San Francisco Examiner* and one from the *Daily Alta California*)." *The Northwesterner*, Spring-Summer 2005.

North, E. M. "Evolution of Shipping and Shipbuilding in California," *Overland Monthly*, 1899.

Ottawa Government Printing Bureau. *The Canadian Patent Office Record*. Ottawa Government Printing Bureau, Ottawa, Ontario, Canada. Vol XXIII, 1895.

San Francisco Call.

San Francisco Chronicle.

San Francisco Examiner.

San Francisco Maritime National Historical Park and San Francisco Maritime Museum Association. *A Brief Chronology of San Francisco Bay Ferryboat History, Draft II*. San Francisco, 1990.

(San Pedro) *News-Pilot*.

Santa Rosa Press Democrat.

Schroder, Eckart, Designers and Planners. "Draft Electrical Survey of the Ferryboat *Eureka*." Prepared for the National Park Service. Arlington, Virginia, Report No. 100-92-006, 1992.

Statesman Journal (Salem, Oregon).

Sunset Magazine.

Thirtieth Annual List of Merchant Vessels of the United States. Washington: Government Printing Office, 1898.

Ukiah Daily Journal.

United States Patent Office. *Annual Report of the Commissioner of Patents for the Year 1895.* Washington, D.C., Government Publishing Office, 1895.

Welts, Allen W., California Department of Parks and Recreation. *Eureka National Register of Historic Places Inventory Nomination Form*. San Francisco, CA, 1973.

UNPUBLISHED SOURCES

Edwards, Christopher, SAFR Park Ranger. "*Eureka* HSR – 50% Draft – Review Comments – Supplemental Information." 2021.

Edwards, Christopher, SAFR Park Ranger. "*Eureka* HSR – 75% Draft – Review Comments – Supplemental Information." 2022.

Bibliography

Edwards, Christopher, SAFR Park Ranger. “Documentation of *Ukiah* New Boiler Installation in 1914.” 2020.

Edwards, Christopher, SAFR Park Ranger. “*Eureka* Physical Chronology.” 2020.

Hijar, Katherine, SAFR Historian. “*Eureka* HSR – 75% Supplemental Draft – Review Comments,” 2022.

National Park Service. National Park Service Project Management Information System Work Log, Ferryboat *Eureka*. Compiled by SAFR, 2021.

National Park Service. National Park Service Planning, Environment and Public Comment Work Log, Ferryboat *Eureka*. Compiled by SAFR, 2021.

National Park Service. National Park Service Staff-Completed Work Log, Ferryboat *Eureka*. Compiled by SAFR, 2021.

Porter, Mark R. “Historic American Engineering Record, Ferry *Eureka,* HAER No. CA-59 (addendum).” San Francisco, CA, 2001.

Schroder, Eckart, Designers and Planners. *“*Draft Electrical Survey of the Ferryboat Eureka.*”* Prepared for the National Park Service. Arlington, Virginia, Report No. 100-92-006, 1992.

Tri Coastal Marine Inc. “Draft Historic Structure Report for *Eureka*.” Prepared for the San Francisco Maritime National Historical Park, San Francisco, 1990.

ONLINE RESOURCES

National Park Service. “National Historic Landmarks.” Website of the National Park Service, accessed October 29, 2021 at https://www.nps.gov/subjects/nationalhistoriclandmarks/list-of-nhls-by-state.htm

Online Archive of California. “California Northwestern Railway Records.” Collection guide accessed March 8, 2022 at https://oac.cdlib.org/findaid/ark:/13030/c80p13cz.

DRAWINGS

Marine Technical Services, LLC. *Paddle Ferry* Eureka *General Arrangement*. 2021.

PHOTOGRAPHS

San Francisco Maritime National Historical Park. Maritime Research Center. Resource Management records, Harry Dring Photographs, 1870-1983.

San Francisco Public Library. San Francisco Historical Photograph Collection.

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